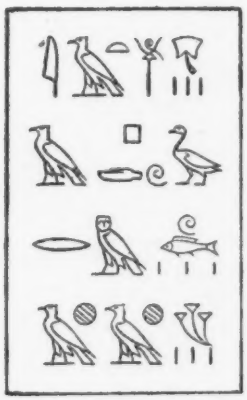
THE JOURNAL OF WILDLIFE MANAGEMENT

UNIVERSITY OF MICHIGAN
NOV 28 1952
FORESTRY LIBRARY



OCTOBER - 1952
Vol. 16 No. 4

16

CONTENTS

Deer Browse Clipping Study in the Lake States Region. *Shaler E. Aldous* 401

A Pheasant Breeding Population Study on Irrigated Lands in Southwest Idaho. *Herbert E. Salinger* 409

Studies in Control of the Prairie Mole. *Willard L. Henning* 419

Techniques Used to Increase Nesting of Canada Geese. *Charles F. Yocom* 425

Variations in Two Spring Indices of Male Ring-necked Pheasant Populations. *Edward L. Kozicky* 429

A Trap and Technique for the Capture of Diving Waterfowl. *I. McT. Cowan and James Hatter* 438

Upland Farming as a Method of Supplementing the Natural Waterfowl Food Supply in the Southeast. *Thomas Z. Atkeson and Lawrence S. Givens* 442

The Source of Migrant Mourning Doves in Southern Florida. *John W. Aldrich* 447

Food Habits of the Golden Eagle. *Wesley Woodgerd* 457

The California Quail in New Zealand. *Gordon R. Williams* 460

Factors Affecting the Survival of the Plains Muskrat in Oklahoma. *B. P. Glass* 484

The Effects of Aldrin on Birds. *George Post* 492

Bobwhite Mobility in Central Missouri. *Dean A. Murphy and Thomas S. Baskett* 498

Reviews. 511

Briefer Articles—A throw net for capturing female waterfowl on the nest, by Stanley W. Harris; The fox as a factor in the control of weasel populations, by Roger M. Latham. 515

Recent Publications. 518

Notes and News. 518

Index for Volume 16. 520

The Journal of Wildlife Management is printed by the Cayuga Press, Inc., and published by The Wildlife Society in January, April, July and October, at 113 East Green St., Ithaca, N. Y. Subscription $5.00 per year and current numbers $1.25. Society members cover subscription in annual dues. Back issues are available; volumes 1 through 8, and 13 at $8; 9 through 12, and others since 1949 at $6 per volume, $1.50 per issue.

Manuscripts for publication, books and papers for review, news notes and correspondence concerning them should be sent to the *Editor*, Gustav A. Swanson, Department of Conservation, Cornell University, Ithaca, N. Y.

Dues, subscriptions, changes of address, requests for missing numbers, applications for membership, and other correspondence should be sent to the *Secretary*, W. C. Glazener, Game and Fish Commission, Austin 14, Texas.

The Society is not responsible for supplying missing issues unless the Secretary is notified within 60 days of the date of publication.

Entered as Second Class Matter, at the Post Office at Ithaca, New York, June 18, 1951, under the Act of March 3, 1879.

Articles in this Journal are indexed in the Agricultural Index, available in many libraries.

THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 16 OCTOBER, 1952 NUMBER 4

DEER BROWSE CLIPPING STUDY IN THE LAKE STATES REGION

Shaler E. Aldous

U. S. Fish and Wildlife Service, Washington, D. C.

To aid in interpreting the findings from browse surveys in wintering deer yards, a clipping experiment on the more important browse species was started in 1937. The aim of the study was to imitate heavy, moderate, and light deer browsing by clipping off various degrees of the annual growth from selected species. In the case of most hardwoods, browsing rarely exceeds the annual growth. Complete utilization of the annual growth is always interpreted as heavy browsing. On evergreens such as white cedar, all the leafy growth and the more succulent twigs are often utilized and therefore more than the current annual growth may be eaten. The study was conducted within deer-and rabbit-proof exclosures on the Superior National Forest, in Cook County Minnesota and in a deer-proof exclosure on the Dukes Experimental Forest in the Upper Peninsula of Michigan.

The species clipped included: northern white cedar, (*Thuja occidentalis*); mountain maple, (*Acer spicatum*); white birch, (*Betula alba var. papyrifera*); mountain ash, (*Sorbus americanus*); red osier dogwood, (*Cornus stolonifera*); pin cherry, (*Prunus pennsylvanica*); red-berried elder, (*Sambucus racemosa*); willow, (*Salix* sp.); and black ash, (*Fraxinus nigra*).

The clipping of hardwoods was done about the first week in November each year in order to have the plants in a dormant condition, and the white cedar was clipped in August after the current season's growth was mostly complete.

In the case of hardwoods, the clipped samples were saved and weighed each evening and then taken to the office where the length of each twig was measured. Weights were taken of some of these twig samples after they had dried at room temperature, in order to ascertain the water content of each species. The white cedar samples were weighed immediately after clipping so that no moisture loss was possible. The trees were measured for height and d.b.h. before clipping, and check plants for each treatment were similarly measured.

White cedar

White cedar, when available, is probably the best single winter browse species for deer in the northern parts of the Lake States. It is both highly palatable and nutritious. In deer concentration areas the reproduction of this species is being kept down by deer, and most of the larger trees have been browsed as high as deer can reach. As the present seed trees are logged off, this species will gradually be reduced in the stand

because no young stock is replacing the harvested trees due to heavy browsing pressure by deer. During the highs of the snowshoe hare cycle these animals add materially to the pressure exerted on white cedar reproduction. Areas protected by fences or in the close proximity of towns are showing good reproduction and growth of cedar, but these stands are too limited in extent to be of any great value to either the deer or the future timber supply.

The clipping study was made in order to obtain information on how much deer browsing white cedar can withstand and still continue to grow.

Two size classes of trees were used in this study. One group was approximately 7 feet in height, and therefore, completely vulnerable to browsing, and the other group consisted of trees up to 15 feet high that had only the lower 7 feet vulnerable. These trees were clipped annually of 25 and 50 percent of the foliage within 7 feet of the ground.

Two comparable sets of unclipped trees were measured each year to serve as checks. All trees used in the study were in closed stands of young trees or brush so as to avoid isolated trees that had the dense foliage extending to the ground. This experiment was carried on for six years, and at the end of that period all the foliage on the clipped trees and the check trees was removed and weighed. This represented seven clippings and six growing seasons after the first clip. The resulting data show the productivity of white cedar under no clipping, 25 percent clipping and 50 percent clipping. Ten trees were used in each category. The unclipped trees served as checks against both the 50 and 25 percent clipped groups. A total of 60 trees was used in this study. Table 1 shows the effects of these various treatments and Plate 11 illustrates the before and after appearance of the clipped trees.

These data can be summed up by saying that small trees, when clipped, expend their growth in foliage production more than in trunk diameter increase. The height was directly affected

TABLE 1.—EFFECTS OF CLIPPING ON NORTHERN WHITE CEDAR
Small Trees

	50 percent clip			25 percent clip			check trees		
	Avg. wt. oz.	Avg. Ht. ft.	Avg. d.b.h. in.	Avg. wt. oz.	Avg. Ht. ft.	Avg. d.b.h. in.	Avg. wt. oz.	Avg. Ht. ft.	Avg. d.b.h. in.
Before clip*	21.6	7.3	.7	22.8	7.0	.61	22.8	7.4	.60
1938 clip	10.8	7.3	.7	5.7	7.0	.61		7.4	.60
1939	7.9	7.6	.78	5.6	7.7	.66		7.7	.78
1940	6.2	8.0	.80	4.5	8.0	.73		8.1	.86
1941	5.2	8.2	.80	5.2	8.2	.75		8.6	.93
1942	4.2	8.3	.80	4.5	8.5	.77		8.8	1.01
1943	3.3	8.2	.80	4.2	8.4	.80		9.2	1.10
1944	2.6	8.2	.86	3.4	8.7	.83		9.6	1.14
Left on tree	2.6			10.1					
Total produced	42.8			43.2			30.4		
Per cent increase during the study	98.1	12.3	22.9	89.4	24.3	36.1	33.3	29.7	90.0

* Computed from curve by Aldous—1941.

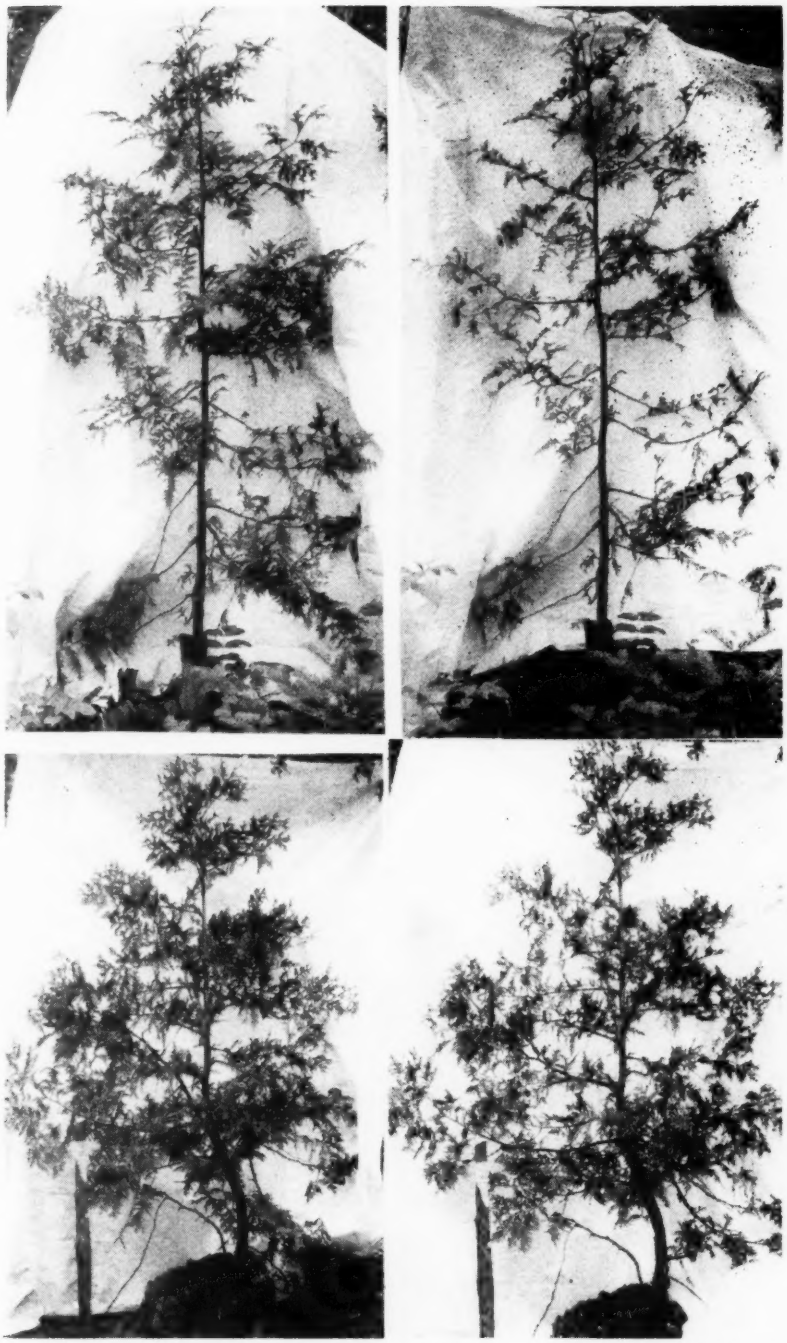


PLATE 11. Northern white cedar. (Above) The same plant before and after a 50 per cent removal of foliage. (Below) The same plant before and after a 25 per cent removal of foliage.

by clipping because the top 6 to 12 inches constituted foliage and was partially removed each year. This made height figures of little value in the final analysis. In the check trees more trunk diameter than foliage growth was evident. Looking at it from a purely timber production point of view, deer browsing definitely retards growth. However, if moderate browsing could be tolerated, growth would be inhibited, but eventually the tree would grow out of reach of deer. At the rate the annual production was decreasing under 50 percent clipping pressure (76 percent less in the last clip than in the first), it would take only about 10 years until available browse would be practically nil, and death to the trees would be quite likely. Even under 25 percent clipping the annual production was on the decline after 6 years (40 percent less browse in last clip than in first), but the loss was much less rapid than under the 50 percent treatment. Removal of somewhere under 25 percent of available browse is necessary to prevent eventual depletion of the foliage. From these figures it seems that something under 15 to 20 percent annual usage of the foliage might maintain a constant food supply and still permit a suitable growth rate for trees of this size.

It is interesting to note that over the 6-year period the trees clipped 25 percent actually supplied more browse than those clipped 50 percent and were in a less depleted condition. The check trees had only a 33.3 percent greater amount of browse after 6 years than was present on the trees when the study started. Whereas the trees clipped 25 and 50 percent actually produced 89.4 and 98.1 percent more browse respectively, than was available when the clipping started. This indicates that if utilization is properly regulated the food production on browsed trees will be as great or greater than on unbrowsed trees and growth will not be materially affected. Weight and growth figures are shown in Table 1.

The situation is quite different on the larger trees where only the foliage below 7 feet was clipped. The clipping had practically no effect on tree growth but did stimulate foliage production so that over the 6 years more was available under clipped conditions than under complete protection. Under the 50 percent foliage removal the production was 97 percent less the last clip than the first, but the amount of browse removed over that period was 12.3 percent greater than what was available when the study started.

When 25 percent of the foliage was removed the trees produced 25 percent more over the study period than was available at the beginning. The last clip, however, was 79 percent less than the first one which showed a definite decline.

On the other hand the check trees contained 51.1 percent less foliage below the 7-foot line at the end of the study than was present at the beginning. Weight and growth data are given in Table 2. Since this lower foliage will be lost through natural pruning, it might as well be utilized by deer.

Hardwoods

There was some variation in the clipping of hardwoods as can be seen in Table 3. Most of the clipping started in 1937 and ended in 1942, but a few species were started in 1938 and 1939.

TABLE 2.—EFFECTS OF CLIPPING ON NORTHERN WHITE CEDAR
Larger Trees

	50 percent clip			25 percent clip			check trees		
	Avg. wt. oz.	Avg. Ht. ft.	Avg. d.b.h. in.	Avg. wt. oz.	Avg. Ht. ft.	Avg. d.b.h. in.	Avg. wt. oz.	Avg. Ht. ft.	Avg. d.b.h. in.
Before clip	54.4	14.0	2.3	70.8	14.9	2.9	56.0	14.2	2.3
1938 clip	27.2	14.0	2.3	17.7	14.9	2.9		14.2	2.3
1939	14.8	14.7	2.5	10.0	15.5	3.0		15.1	2.5
1940	5.8	15.4	2.7	5.5	16.3	3.1		16.1	2.6
1941	6.2	15.7	2.7	6.3	17.0	3.4		16.6	2.8
1942	3.5	16.3	2.9	4.1	17.3	3.5		16.9	2.9
1943	2.0	16.6	3.0	2.6	17.9	3.6		17.4	3.1
1944	.8	16.4	3.1	1.4	18.2	3.8		17.6	3.2
Left on tree	.8			5.4					
Total produced	61.1			53.0			27.4		
Percent change during the study	12.3	17.1	34.8	−25	22.1	31.1	−51.1	23.9	39.1

Some received fewer types of treatment due to growth characteristics or plant location. In the case of hazelnut, the annual growth was so short that a 50 percent clip was not practical. Too few bushes of red osier dogwood were available within the inclosures to use all intensities of clipping, so the 50 percent one was omitted. The treated bushes of black ash, pin cherry, and red-berried elder were not all inside the inclosures so only heavy or 100 percent clips could be made on those on the outside. Otherwise deer browsing might have interfered with results.

In discussing each species and in studying Table 3, it must be remembered that the percentage increase or decrease under the various treatments was based on the initial clip in each type of treatment, which was rated as 100 percent. The light clip may have produced a larger percentage increase through the years than the heavily clipped plants, but the actual poundage production and drain on the plants would be much less.

Mountain maple

Mountain maple is one of the staple winter foods of deer in many areas in the northern parts of the Lake States. In certain parts of northeastern Minnesota it is the most prevalent food. The heavy browsing pressure it withstands is one reason for its good survival and its importance to deer. This clipping study has shown that the heavier this species is utilized, the better it produces. The removal of 100 percent of the annual growth for 6 years showed an annual production trend above the first clip. At the end of that period the annual production weight was 110 percent above the first year's clipping. The average length of twigs steadily increased so that they were 39 percent longer at the end of the period. On the other hand, the number of twigs decreased 33 percent. The peak of the production was reached the fifth year, but dropped off slightly in the sixth. This may have been a reflection of weather conditions, or it might indicate

TABLE 3.—PRODUCTION OF HARDWOOD BROWSE UNDER VARYING DEGREES OF CLIPPING TO IMITATE BROWSING, BASED ON PERCENTAGE OF FIRST YEAR'S CLIP WHICH IS CONSIDERED 100 PERCENT

	Weight of Clip			Total Length of Twigs			
	Heavy	Moderate	Light	Heavy	Moderate	Light	Check
Mountain Maple							
1937..	100	100	100	100	100	100	100
1938..	179	119	124	145	128	120	99
1939..	146	86	109	125	92	104	107
1940..	195	107	139	148	111	130	101
1941..	240	125	158	159	118	128	137
1942..	210	114	189	139	131	165	115
White Birch							
1937..	100	100	100	100	100	100	100
1938..	226	158	96	196	130	101	195
1939..	352	202	137	277	169	139	226
1940..	344	190	200	295	166	206	277
1941..	362	260	194	283	189	152	400
1942..	262	281	*	206	252	*	*
Beaked Hazelnut							
1937..	100	...	100	100	...	100	100
1938..	186	...	137	157	...	130	145
1939..	230	...	120	196	...	121	170
1940..	258	...	111	229	...	106	220
1941..	216	...	121	194	...	117	247
1942..	199	...	121	184	...	121	322
Mountain Ash							
1937..	...	...	100	...	...	100	100
1938..	...	...	140	...	...	127	310
1939..	100	100	150	100	100	146	345
1940..	63	138	190	136	157	218	384
1941..	60	147	100	140	163	91	450
1942..	42	100	190	133	171	182	615
1943..	44	76	...	158	114	...	...
Red osier Dogwood							
1938..	100	...	100	100	...	100	100
1939..	103	...	405	87	...	195	109
1940..	140	...	186	136	...	207	90
1941..	138	...	205	160	...	220	144
1942..	125	...	290	130	...	308	133
Willow							
1938..	100	100	...	100	100	...	100
1939..	420	348	...	223	150	...	133
1940..	736	220	...	285	190	...	151
1941..	877	218	...	314	178	...	166
1942..	955	264	...	291	218	...	127
Black Ash							
1938..	100	...	100	100	...	100	...
1939..	119	...	109	121	...	133	...
1940..	450	...	162	413	...	160	...
1941..	480	...	157	413	...	110	...
1942..	408	...	176	532	...	200	...
Red-berried Elder							
1939..	100	...	...	100	...	...	...
1940..	217	...	...	51	...	...	...
1941..	62	...	...	25	...	...	...
1942..	138	...	...	44	...	...	...
1943..	167	...	...	54	...	...	...
Pin Cherry							
1938..	100	...	...	100	...	...	100
1939..	188	...	...	210	...	...	123
1940..	221	...	...	157	...	...	120
1941..	207	...	...	154	...	...	190
1942..	195	...	...	142	...	...	239

* Out of reach of deer.

that the peak had been reached and henceforth production would be more stable.

Under moderate use (50 percent clipping of current annual growth) the weight was only 14 percent higher than the first clip at the end of the 6 years, the average length increased 31 percent, and the number of twigs increased 94 percent.

Under light usage (tips clipped), the weight increased steadily until it was 89 percent above the first clip. The total length of twigs produced increased 65 percent, but the number of twigs increased 115 percent.

The check plants showed a steady increase in number of twigs up to 202 percent, but the total length increased 37 percent in 1941 and dropped to 15 percent the following year.

The plants clipped lightly and the checks grew out of deer reach at the end of 3 years. This indicates that mountain maple must be used moderately or heavily in order to remain available to deer. It has no commercial value so its management for deer is highly desirable. These data explain why mountain maple is commonly the dominant brushy vegetation in many overpopulated yarding areas. This species is still producing well after being subjected to heavy usage by deer for over 20 years.

White birch

White birch, both as seedlings and as sucker growth around stumps, is an important deer food in many sections of the northern deer range. Twig growth is rapid and is accelerated by both heavy and moderate clipping. Under heavy clipping the twig production increased 126 percent the second year and

252 percent the third year. The fourth year showed a slight decrease to 244 percent, and there was an increase to 262 percent in the fifth year. The last year a big decrease over previous years' production occurred when only 162 percent increase over the first clipping was obtained. This sharp decline probably signifies that the productive capacity had been reached, and that, thereafter, the output would either be more stable or on the decline.

Moderate clipping showed a more even increase and the sixth year's production showed an increase of 184 percent over the first clip. An increase in browse production was obtained from light clipping amounting to 94 percent in the fifth year, but the actual quantity produced was of little value. Under this degree of use, the plants grew out of reach of deer by the fourth year after the first clipping.

There was little difference in the productivity of the plants lightly clipped and those used as controls. Their curves of productivity were almost parallel, and both groups rapidly grew above the reach of deer. Even the moderate usage was insufficient to keep the plants from attaining heights above deer browsing possibilities.

It was concluded that white birch can withstand moderate to heavy usage over a period of at least 5 or 6 years and must be used quite heavily if it is to remain in the browse category. If these trees are being managed for timber, then deer browsing must be reduced to the light category.

Beaked hazelnut

Beaked hazelnut has a wide distribution although its palatability rating is only fair. Because of its growth habits, it was practical to make only heavy and light clippings.

Under heavy use the production increased for 3 years after the first cut and then declined the next 2 years. The maximum increase amounted to 158 percent, but this dropped during the next 2 years to 116 and 99 percent, respectively. Under light use there was a 37 percent increase the second year, but thereafter it ranged between 11 and 21 percent increase. Considerable suckering took place in the plants clipped heavily with a resultant decrease in regular twig growth. This made the figures on the number of twigs produced so erratic that they have no significance.

In the check plants the number of twigs increased steadily each year, but because this species is characteristically a low form, it does not often grow out of reach of deer. In order to obtain maximum production from this plant, moderate to heavy usage is recommended.

Foresters would like to see this species utilized more heavily by deer, but because of its low palatability rating, such usage would require a deer herd so large that the more desirable browse and timber species would be seriously affected before the hazelnut would be properly controlled.

Mountain ash

Mountain ash is one of the most palatable of the deer foods, but its availability is quite limited. From general field observations and the clipping study, it is believed that this poor availability is due to excessive deer browsing. Small plants of this species are locally abundant, but they are kept down by con-

stant deer browsing. Wherever this species occurs in deer territory, it is heavily utilized. Snowshow hares and ruffed grouse relish mountain ash and add materially to the pressure on this species.

Under heavy use as demonstrated by clipping, there was a progressive decline in productivity until the third year after the initial clip. The production was down 68 percent the third year but came up 2 percent in the fourth year. Under moderate clipping the plants produced good increases (38 and 47 percent) the second and third years but declined the next 2 years to the original production and then down 24 percent. Under light clipping there was an increase of browse amounting to 40, 50 and 90 percent for the first 3 years, respectively. It then dropped to par the following year and had an upswing of 90 percent again the next year. The check plants showed an even trend upward in growth and productivity. Apparently this species cannot withstand more than light usage and remain productive.

Red osier dogwood

Red osier dogwood is one of the favorite foods of deer, but its distribution is rather spotty. Its need for damp, open sites largely precludes its existence in timber stands or on well-drained areas.

Heavy clipping of this species produced only a small increase in its output of browse the second year—3 percent. The third year it increased 40 percent but declined during the next 2 years to 38 and 25 percent above the initial clip. Under light clipping the plants responded with a heavy output the second year, but during the next 3 years the production was less but still well above the initial clipping.

Evidence from the clipping data and field observations indicates that this browse species cannot hold up under repeated heavy use. The bushes become spiny and the growth retarded.

Pin cherry

Pin cherry is used moderately by deer but is not generally present in quantity in Minnesota yarding areas. Its chief value is during late winter and spring after the deer leave the concentration areas, as its distribution is best in the old burns which so often adjoin or encompass the yarding areas.

It responded well to heavy clipping. Four years of clipping after the initial cut produced increases varying from 88 to 121 percent. No differential clipping was possible due to the lack of sufficient plants within the inclosures. The length of twigs under protected conditions showed an increase somewhat in excess of that produced on the heavily clipped bushes.

Willow

Over the Lake States deer range willow is more important as a summer than a winter food. This species responded to heavy clipping more than any other plant in the experiment. The annual production of browse increased steadily each year until at the fifth clipping, it had increased 855 percent. This enormous production was accomplished by the growth of larger but fewer stems each succeeding year. The number of stems was reduced 41 percent in the final clip. Under moderate usage there was an increased production of 248 per-

cent the second year and then a more stable production between 118 and 164 percent above par the next 3 years. The number of twigs remained much more stable than under heavy usage.

Red-berried elder

Red-berried elder is not commonly found in abundance in or near deer yards. This may be because it cannot withstand prolonged heavy use. This species is usually heavily browsed where deer are at all plentiful.

The plants were very erratic in their response to heavy clipping. The second clipping showed a large increased production (117 percent); the third year they dropped to 38 percent below par; and then, in the next 2 years they produced 38 to 67 percent, respectively, more than the first year. This species was not found in the inclosures which made it necessary to clip heavily in order to avoid complications from regular deer browsing.

Black ash

Black ash has poor distribution in deer yarding areas and young sucker growth is usually preferred. Therefore, it is not considered an important browse species. It responded well to heavy clipping, by producing a 19 percent increase the second time it was clipped and over 300 percent each successive year. It is the only species in which both the number of twigs and the average length of twigs increase at the same time. On other species studied, the number of twigs usually decreased when the average length increased and vice versa.

Water content of browse species

The water content of some of the browse species discussed in this paper is shown in Table 4. These figures may have value in future studies where feeding and carrying capacities are involved. Most nutritional studies are based on air-dried weights, so the ones here recorded were air-dried at room tempera-

TABLE 4.—WATER CONTENT OF SOME OF THE IMPORTANT DEER BROWSE TWIGS

Species	Parts Weighed	% Water	Basis No. of Twigs
Black Ash	Tips of Twigs	35.4	42
	100% Annual Growth	34.8	80
Pin Cherry	100% Annual Growth	44.0	181
Paper Birch	Tips of Twigs	42.7	181
	50% Annual Growth	40.7	1498
	100% Annual Growth	39.5	792
Willow	50% Annual Growth	46.2	535
	100% Annual Growth	47.9	349
Red Elder	100% Annual Growth	58.6	23
Red Osier Dogwood	Tips of Twigs	41.2	282
	100% Annual Growth	44.5	429
Hazelnut	Tips of Twigs	36.1	966
	100% Annual Growth	42.2	656
Mt. Ash	Tips of Twigs	48.2	34
	50% Annual Growth	50.6	13
	100% Annual Growth	51.7	24
Mt. Maple	Tips of Twigs	47.5	3205
	50% Annual Growth	48.0	1691
	100% Annual Growth	49.3	906

tures so as to be usable for such studies.

Contrary to expectations only black ash and paper birch had greater water content in the tips of the twigs than in the whole twig. Willow, red osier dogwood, hazelnut, mountain ash and mountain maple had more moisture in the whole twigs than in the tips only.

CONCLUSIONS

Northern white cedar under 7 feet tall will produce well and continue to grow when something under 15 to 20 percent of the foliage is removed annually. Heavier usage causes a decline in browse production, retarded growth and gradual death to these small trees. Larger trees can be browsed heavily below the 7-foot line without injuring the trees. Usually the lower foliage is lost by natural pruning, so browsing is actually a means of utilizing that which would otherwise be wasted.

Mountain maple, white birch, beaked hazelnut, pin cherry, willow and black ash produce well under moderate to heavy usage and should be utilized at least moderately if the plant growth is to be kept within reach of deer.

Mountain ash, red osier dogwood and red-berried elder do not stand up well under heavy usage and should therefore be moderately utilized where possible, to insure their continued availability to deer.

LITERATURE CITED

ALDOUS, SHALER E. 1941. Deer Management Suggestions from Northern White Cedar Types. Jour. Wildl. Mgt., 5(1): 90–94.

Accepted for publication Oct. 19, 1951.

A PHEASANT BREEDING POPULATION STUDY ON IRRIGATED LANDS IN SOUTHWEST IDAHO [1]

Herbert E. Salinger

2030 Main Street, Napa, California

INTRODUCTION

The effects of farming practices on a pheasant (*Phasianus colchicus torquatus*) breeding population in irrigated lands in southwest Idaho were studied during the nesting seasons of 1949 and 1950.

The number and density of nests in hayfields provide an excellent opportunity to study clutch sizes, fertility, and the over-all effects of mowing operations.

Non-hayfield nests are usually more difficult to find, but are the key to pheasant production in any area where alfalfa and clover crops predominate. Their comparative success with hayfield nests is important and should be ascertained.

The study was carried out on the 53,869-acre Gem Irrigation District, a

[1] Contribution from the Idaho Cooperative Wildlife Research Unit: the University of Idaho, the Idaho Department of Fish and Game, the United States Fish and Wildlife Service, and the Wildlife Management Institute cooperating.

The writer wishes to express his thanks and appreciation to Dr. Paul D. Dalke, Leader of the Idaho Cooperative Wildlife Research Unit, for his valuable aid during the study and in preparation of this paper; to the Idaho Department of Fish and Game; and the residents and farmers of the Homedale-Marsing, Idaho area for their generous assistance.

part of the Bureau of Reclamation Owyhee Project in southwest Idaho. The Gem District lies between Homedale and Marsing adjoining the Snake River in Owyhee County, Idaho. There are 30,448 acres of cultivated lands, and 23,421 acres uncultivated of greasewood (*Sarcobatus vermiculatus*), shad scale (*Atriplex canescens*), and associated plants growing on a black alkali desert composing the Gem District lands. The principal agricultural crops are alfalfa, sugar beets, small grains, and potatoes. Over one-third of the cultivated acres were in hay crops during the 1949 and 1950 nesting seasons.

METHODS

Mowing of hayfields (clover and alfalfa) was the major farming practice which affected pheasants on the study area. Information on hen mortality and nest destruction was gathered by personal observation and from interested farmers on representative tracts. Data were accumulated during the three mowings in 1949 and the first mowing of hay in 1950. Farmers were asked to tabulate the number of birds flushed as well as killed during the last two cuttings in 1949 and the first mowing in 1950. The nesting study was carried on by intensive and extensive nest searches during 1949 and 1950.

In the spring of 1950 an intensive study of non-hayfield nests was undertaken. Farmers over the entire study area were contacted in early spring and asked to keep all nests found under surveillance and to report on them at a later date. Daily trips were made to these farmers during the nesting season prior to the mowing of alfalfa. All nests reported were visited and revisited to ascertain date of hatching, success, cause of desertion or mortality.

Hayfield nests were searched for immediately following the flushing or killing of the hen. The number of eggs in each nest found were recorded and examined for length of incubation and fertility.

A search for successful nests was carried on in small grain fields following harvest. The fields were walked in grids. An estimated four feet on each side was used as the allowable width of observation. Combining left stubble too high for observations of most nests. These fields were surveyed after they had been mowed later. We tried to be present when a grain field was being harvested by a binder, as the farmer riding the binder was usually unable to see any nests present.

NESTING STUDY

Non-hayfield Nests

Twenty-nine nests were located by farmers in non-hayfield cover and subsequently observed by the investigator prior to the mowing season. All nests were relocated once and then not visited again until the approximate date of hatching.

Site preferences of nests in other than hayfield cover seemed to be determined for the greater part by the amount of available herbage present. The majority of the non-hayfield nests were found in uncultivated cover types which afforded the greatest herbage protection for early-nesting hens.

Twenty-seven of the 29 nests located in non-hayfield cover were in uncultivated areas. Eleven of the nests were found on ditch banks, four in thick growth of alkali weeds, and the re-

mainder in fence row, orchard, field edge, greasewood, shad scale, bull thistle, and sagebrush cover. One nest was found in the middle of a livestock corral.

Only two nests were found in cultivated fields prior to the 1950 harvest. One nest was in a wheat field and the other nest was in an onion field. Eight nests were found in 161 acres of small grains checked for nests in the summer of 1949.

Nesting site quality was based on the amount of cover surrounding a nest. Four representative categories were chosen—Excellent: nest surrounded by a good growth of cover from all sides and on top; Good: nest surrounded by cover but not on top; Fair: nest not surrounded by cover on all sides, growth light; Poor: nest in open or protected by sparse cover.

The site quality of the 29 non-hayfield nests was: excellent, 4; good, 14; fair, 9; and poor, 2.

The site quality did not seem to affect the success of the nests. None of the nests in "excellent" cover hatched. Two nests hatched from "good" sites and one each from the "fair" and "poor" sites.

Nest destruction was determined for 38 of the nests under observation during the spring of 1950. Table 1 summarizes the types of destruction.

Man and his effects caused 42.5 per cent of the known nest destruction. Known predation amounted to only 5 per cent. The most important single effect other than unknown causes was mechanical destruction due to farming operations, i.e. plowing, tractors, disking, etc.

The three nests destroyed on the 161 acres of small grains examined in 1949 were a result of mechanical destruction. Only three of the nest desertions indicated in the 1949 and 1950 observations were caused by the death of the hen.

TABLE 1.—CAUSES OF NEST DESTRUCTION AND HEN DESERTION FOR 38 PHEASANT NESTS IN PERMANENT COVER, GEM IRRIGATION DISTRICT

Type	Number of nests	Per Cent
MAN		
Mechanical (Disking, Plowing, Tractor, etc)	9 ND	23.7
Burning	6 ND	15.8
Irrigating	2 ND	5.3
PREDATORS	2 ND 2 HK	5.3
OTHER		
Dog	3	7.9
Microtus sp.	1 D	2.6
UNKNOWN	15 ER	39.4
Total	38	100.0

ND — Nest destroyed, hen not killed.
HK — Hen killed.
ER — Eggs removed, hen deserted.
D — Hen deserted (caused when nest was covered with dirt while *Microtus* were tunneling nearby).

The cooperation of farmers in reporting nests found during their normal daily activities helped reduce any possibility of nest desertions caused by the research worker.

Hayfield Nests

The late inception date of the study in 1949 prevented the investigator from contacting the majority of the farmers before the mowing period. Personal observations were limited to 77 acres. Sixteen destroyed nests (1 nest per 4.8 acres) and a week-old brood were found in the mowed hayfields checked during the first mowing period. Eighty-eight

nests were found on the 1,023 acres of hayfields in 1949.

Time and excellent cooperation from the farmers on the study area during the spring of 1950 permitted an intensive study on 841 acres of alfalfa and clover. Farmers were asked to count the nests destroyed and determine the clutch size. One hundred and sixty-six nests were found by cooperating farmers on 641 acres (one nest per 3.86 acres). Seventy-one nests were found on the 210 acres personally checked (one nest for every 2.96 acres). The 0.9 nest per acre difference between the farmers' data and personal data can be accounted for by the fact that the investigator could spend more time searching for nests than the average farmer who was mowing.

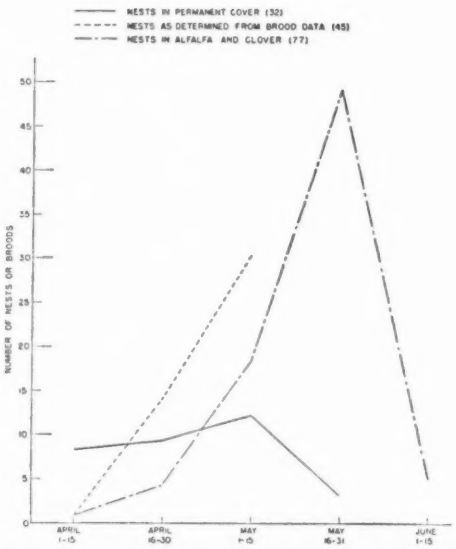


FIG. 1. Approximate dates of nest establishment in permanent and hayfield cover as calculated from observed nests and broods.

Broods were not used in determining the nest per acre data, as there was no way of finding out whether the brood hatched in nearby cover or in the hayfield. There was 100 per cent nest mortality of the 237 nests found in hay and clover fields. Only 5 successful nests were found out of the entire 270 nests discovered in hayfield and non-hayfield cover.

Nesting Peaks

The renesting ability of the hen pheasant compensates in part for this high nest mortality. Buss (1946) has shown the possibility of double nesting curves caused by renesting attempts of hens whose nests were destroyed.

The data at hand suggest the possibility of even a third peak. The first peak is apparent in other than hayfield cover. A second peak in hayfield cover, and a third peak which is not shown (Fig. 1) can be expected in hayfield and other covers resulting from the high nesting mortality during the mowing. Using the ratio of one nest per 2.96 acres, we find that a possible 3,482 nests were destroyed on the 10,308 acres of alfalfa and clover during the first cutting on the Gem District. The renesting attempts of even a small per cent of the surviving hens along with the late nesters could result in a definite third nesting peak.

Hens Nesting in Hayfield Cover

The calculated number of nests in hayfields and the pre-breeding season population of hens show that probably 58.6 per cent of the breeding hens on the study area were nesting in hayfields during the first mowing in 1950.

Comparative Nest Success

The small sample in grain fields is not large enough for accurate compari-

son but indicates a higher nesting success. Only a small number of hens nest in grain fields (approximately one nest for 20 acres) as compared with the one nest in every three acres of alfalfa and clover.

An example of nesting success in small grains is demonstrated by the farmer on the Gem District who had 63 acres in alfalfa and 63 acres of grain. Three successful nests were found on the 63 acres of grain, while the 9 nests found in the 63 acres of alfalfa were destroyed.

The clue for success in the various types is closely related to the nesting and harvesting dates. The hens nesting in grain are comparatively safe because of the later harvesting date.

Leedy (1949) in his Ohio study points out that "only about one-fifth of the nests reported in the first cutting of alfalfa have hatched at the time of harvest compared with about three-fourths of the nests in wheat." Randall (1939) shows an increasing success in hayfields from 9.1 per cent in early June to 37.0 per cent at the end of the month. The even smaller success ratio on the study area hayfields is probably due to the late peak of nest establishment during the spring of 1949 and 1950. Weather conditions and the physiological factors that affect nesting may differ from year to year with a resulting increase or decrease in nesting success.

Nest Establishment

Approximate dates of nest establishment were determined for nests in hayfields and non-hayfield cover during the spring of 1950. The dates were determined from clutch size, length of incubation, and the assumption that one egg is layed per day. A correction factor of 5 days was subtracted to compensate for the variance in egg-laying during the first week and subsequent interval between eggs. Figure 1 shows a gradual increase of nest establishment in non-hayfield cover from April 2 until a peak is reached in early May. The drop off from this peak is probably due to the increased cover offered by hay crops and the resultant movement of nesting hens into this cover. The nest establishment in alfalfa and clover starts with a gradual increase in late April corresponding to the increased growth of alfalfa. The high point of nest establishment in mid-May coincides with the increased cover.

Forty-five broods observed during the first mowing of alfalfa and clover were placed in weekly age groups and the data obtained pertaining to approximate date of nest establishment were used to supplement the nest data. Brood data were kept separate because of the doubt as to where the brood came from when seen in hayfields.

Weather

There is a possible correlation between nest establishment and weather influences during the spring of 1950. A minimum temperature of 21° F. was recorded as late as May 6 and above-average precipitation for March and April may have caused late establishment dates. Alfalfa growth was retarded due to the cold weather and good cover was not present in hayfields until the first week in May. Killing frosts April 24 and April 26 caused the replanting of many acres of beets and prevented the budding of the majority of alfalfa and clover on the study area.

Clutch Size

An average clutch size of 9.3 eggs was found for 25 complete clutches observed prior to June 15, 1949. Twenty-three of these nests were found in hayfields and the remaining 2 in non-hayfield cover.

The average clutch size of 10.3 eggs was computed from 127 complete clutches found in permanent and hayfield cover before June 15, 1950. Seventy-seven incubated clutches were placed in half-monthly periods in relation to the date of nest establishment. Table 2 shows the average clutch size for these periods.

TABLE 2.—AVERAGE CLUTCH SIZE IN RELATION TO DATE OF NEST ESTABLISHMENT ON THE GEM DISTRICT, SPRING, 1950

	April 1–15	April 16–30	May 1–15	May 16–31	Total
Number of clutches	11	6	15	45	77
Average number	11.2	11.5	12.1	9.8	11.1 (av.)

The diminishing clutch size as the nesting season progresses has been observed previously by other writers. Hamerstrom (1935) showed this fact during a three-year nesting study.

Fertility

Five hundred and nine incubated eggs in destroyed hayfield nests were checked for fertility. Only 5 of the eggs checked were infertile. The 99.02 per cent fertility of the eggs is comparable with the egg fertility as found in other studies. Twining *et al.* (1948) found a 95.1 per cent over-all fertility of 1,559 examined eggs.

FARMING PRACTICES

The driving of a tractor through a field, digging of a fence post hole, and dragging a ditch all may affect pheasant production in a minor way. Observations have shown that a nesting hen may be killed by a post hole digger, a tractor wheel, a plow or disk. More common and yet not so noticeable are the farming practices that result in nest desertion or destruction with no accompanying hen mortality. The dragging of a ditch has the effect of destroying good nesting cover and forcing nesting hens into hayfield crops to renest and later to be killed or crippled by a mowing blade. The more general effects on pheasant production due to farming practices are a result of irrigation, burning, plowing, and harvesting of hay and grain crops.

Mowing

Mowing of hayfields and pastures resulted in more pheasant losses and nest destruction than all other farming practices on the study area combined. Table 3 shows the total pheasant mortality for the three cuttings of hay crops in 1949 and the first mowing in 1950.

The first cutting in 1949 was delayed prior to and during the mowing period by intermittent rain.

A count on the number of birds flushed as well as killed was started during the second mowing period in 1949 and recorded during the subsequent mowing periods. Table 4 gives these additional data.

The kill of one hen per 7.76 acres in the first mowing of 1950 is comparable to that of one hen per 7.69 acres mowed in 1949. The big difference between the data for the two years occurred because the peak of mowing was earlier in 1949, and although coinciding with the peak of nesting, did not have any effect on

TABLE 3.—TOTAL PHEASANT MORTALITY DURING THE THREE CUTTINGS OF HAY IN 1949 AND THE FIRST MOWING IN 1950 ON THE GEM IRRIGATION DISTRICT

	MOWING PERIOD					
	1st mowing 1949 June 5–29	2nd mowing 1949 July 23–August 12	3rd mowing 1949 September 5–October 7	Subtotal 1949	1st mowing 1950 June 5–15	Total
Acres mowed.....	1,023	1,017	1,058	3,098	1,406	4,504
Pheasants Killed:						
Hens.....	133	47	10	190	180[1]	370
Cocks.....	0	7	2	9	1	10
Juveniles.....	0	25	0[2]	25	77	102
Unclassified.....	0	0	28	28	0	28
Total Killed.....	133	79	40	252	258	510
Acres Per Hen Killed	7.7	22.5	110.7	16.3	7.8	.....
Acres Per Total Kill	7.7	13.4	27.6	12.3	5.5	.....

[1] Forty-three hens crippled in addition to above 180. No data on crippled hens kept during other mowings.
[2] Unclassified pheasant group may include juveniles.

TABLE 4.—PHEASANT MORTALITY COMPARED WITH PHEASANTS FLUSHED DURING THE SECOND AND THIRD MOWING PERIODS IN 1949 AND THE FIRST HAYFIELD CUTTINGS IN 1950 ON THE GEM DISTRICT

	MOWING PERIOD		
	Second mowing 1949 July 23–Aug. 12	Third mowing 1949 Sept. 5–Oct. 7	First mowing 1950 June 5–29
Flushing data acres	201	680	956
Hens:			
flushed	15	17	284
killed	14 (49)	7 (29)	138 (30)*
crippled	**	**	38 (8)
Juveniles:			
flushed	114	0***	54
killed	17	10	77
Cocks:			
flushed	2	14	18
killed	3	1	0
Unclassified:			
flushed	0	330	0
Total pheasants:			
flushed	131	361	356
killed	34	18	215

* Figures in parentheses are percentages.
** No data collected on crippled birds.
*** Unclassified pheasant group may include juveniles.

broods due to the almost complete dearth of juveniles from the hayfields. The peak of nesting in 1950 was almost identical with the 1949 peak but the majority of farmers delayed their mowing 7 to 10 days due to rains during the first week of June. This later mowing date resulted in a juvenile loss which was not found in 1949. The 77 juveniles killed on the 1,406 acres mowed during the first cutting of 1950 represent a small percentage of the young that are killed and not found. Many of the young run into by the mower scatter and become easy prey to California gulls (*Larus californica*) and crows (*Corvus brachyrhynchos*) following the tractors. Others die when not able to stand the cooler evening temperatures. Fourteen of the hens killed were accompanied by broods from one day to two weeks old. The majority of the young of these hens escaped, but it is highly improbable that they were able to survive. The late mowing did

not alleviate hen mortality to any noticeable extent. Fifty per cent of the 45 broods found in cut hay and clover fields contained less than week-old birds. Only eight broods were found in the 2-4 week class.

The effect of hen mortality on the hen population as a result of mowing can be determined from the 1950 first cutting data and the pre-breeding season hen population. Approximately 22 per cent of the hen population was lost during the first cutting of hayfields. Approximately 31 per cent of the hen population was lost in 1950 if the 1949 losses during the second and third mowings can be used as criteria.

The data from the second and third mowings of hayfields in 1949 show an increasing higher percentage of birds flushed from the fields. The increased age of the juveniles and the later mowing date were reflected in the light juvenile mortality. The total pheasant loss is more important during the second and third mowing because the losses are among older juveniles which might have lived to become part of the pheasant harvest.

Alfalfa Versus Clover

An attempt was made during the first cutting of hayfields in 1950 to show the nesting densities for alfalfa as compared with clover (the term clover includes red, yellow, and ladino varieties).

Eight hundred and fifty-one acres checked for nests and mortalities were used for the comparison.

Table 5 shows the nesting densities and hen kill in each type.

The data show 14.1 per cent more nests destroyed and 11 per cent more hens killed in alfalfa than in clover. Buss (1946) points out that a lower nesting density was apparent in new hayfields as compared with old ones. No attempt was made to classify the above fields in new or old categories.

TABLE 5.—NESTING DENSITIES AND HEN KILL IN ALFALFA AND CLOVER FIELDS DURING FIRST CUTTING, 1950

Hayfield type	Acres mowed	Nests	Acres per nest	Hens killed	Acres per hen kill
Alfalfa	660.5	190	3.48	105	6.29
Clover	190.5	47	4.05	27	7.06

Harvesting of Grains

One hundred and fifty-six acres of small grains were examined for hen mortality and nests in 1949.

The majority of the small grains were harvested by combine. The late date of combining and the high position of the cutter bar (6-10 inches from the ground) tend to protect hens and young pheasants. The majority of the hens are through nesting by late July, and the cutting blade is high enough for hens with broods to run or fly out of its way. No pheasants were killed on the 46 acres harvested by combine.

Binding of small grains is usually a little earlier than combining. The cutter bar is lower and there is more opportunity for pheasant mortality. No pheasants were killed and three successful nests were found on the 110 acres harvested with the binder.

The mowing of grain stubbles is prevalent on combined small grain fields. Twenty-eight acres were visited during the mowing of stubble. Two hens, one nesting and the other without a nest or brood (probably loafing) were killed. The hen on the nest had been unharmed a week before when the field had been

combined. Mowing of stubble is not a serious cause of hen mortality as the majority of the stubble is not mowed until late fall.

Plowing and Disking

Ten acres of alfalfa, 16 acres of clover, and 10 acres of Australian field peas were checked by the investigator for pheasant and nest mortality while being plowed as mulch for early potatoes during June, 1950. One hen was killed and 4 nests were destroyed on the 36 acres. One hen was killed on May 10 when a farmer disked an 8-acre alfalfa field. Two nesting hens were killed in June, 1949, when 5 acres of barley were plowed by a farmer.

Disking and plowing of nitrogen-building crops is not prevalent enough in the spring to cause much concern, although the loss of 2 hens on 44 acres plowed and disked in the spring of 1950 demonstrates the vulnerability of hens even in fields not mowed.

Burning

Burning by farmers in the spring and fall is a probable cause of some pheasant mortality in other cover types. Burning is a common farming practice along fence rows, ditch banks, roadsides, and uncultivated areas. The removal of this potential nesting cover cannot be adequately measured in the final computations of hatching success but the removal of this cover doubtless prevents the nesting of some hens who later become the victims of a cutting bar in an adjoining alfalfa or clover field.

Nine of the 38 nests (15.8 per cent) found in permanent cover on the study area were destroyed by burning.

Other Farming Practices

Many farming practices result in hen mortality or nest desertions which are less apparent. Nest desertion due to irrigation, beating down of alfalfa and clover in orchards, spraying of fields with 2-4,D, or movements of tractors are all minor contributing factors to nest desertion and hen mortality.

SUMMARY

The study area was the Gem Irrigation District in northwest Owyhee County, Idaho. The 53,000-acre area was chosen as typical of irrigated lands.

Over a third of the cultivated acres were in hay production during the 1949 and 1950 growing seasons. A little less than 50 per cent of the Gem District land area was uncultivated. The important plants in the uncultivated areas were greasewood, shad scale, and associated plants.

Man and his effects caused 42.5 per cent of the known nest destruction.

Sixteen destroyed nests (1 per 4.8 acres) were found after searching 77 acres during the first cutting of hayfields in June, 1949.

Farmer-cooperators and the investigator found 237 nests during the first mowing of 810 acres of alfalfa and clover in 1950.

Only five successful nests were found out of the entire 270 nests discovered in hayfield and non-hayfield cover during 1949 and 1950. This figure does not take into consideration the increased success accompanying renesting attempts and late mowings of hayfields. A possible third nesting peak is shown as resulting from renesting attempts by flushed hayfield hens.

A probable 58.6 per cent of the breeding hens on the study area were nesting in hayfields during the first mowing in 1950.

A gradual increase in nest establishment was noted in non-hayfield cover from April 2 until a peak was reached in early May. The high point of nest establishment in mid-May coincides with the increased cover. Late nest establishment dates may have resulted from the atypical weather conditions during the spring of 1950. The peak of nesting coincided with the peak of mowing in each year.

An average clutch size of 9.3 eggs and 10.3 eggs was found in 1949 and 1950 respectively. A diminishing average clutch size from 11.2 (April 1-15) to 9.8 (May 16-31) was observed. Only 0.9 per cent of the 509 incubated eggs examined in destroyed hayfield nests were infertile.

One hundred and thirty-three hens were killed during the first mowing of 1,023 acres of hay and clover in 1949 while 180 hens and 77 juveniles were killed during the first cutting of 1,406 acres in 1950. An additional 38 hens were crippled during this mowing period. A total of 119 pheasants were killed on a comparable acreage during the last two mowing periods in 1949.

Harvesting of grains is carried on too late to have any detrimental effects on nesting hens.

Other pheasant losses or nest destruction due to farming practices can possibly be attributed to mowing of grain stubbles, plowing, disking, burning, irrigation, tractors, and spraying.

LITERATURE CITED

BUSS, I. O. no date. (1946). Wisconsin pheasant populations. Fed. Aid in Wildlife Restoration Project 9 R, Wisconsin Conservation Dept. 184 pp.

HAMERSTROM, F. N., JR. 1935. A study of the nesting habits of the ring-necked pheasant in northwest Iowa. Iowa State Coll. Jour. of Science. **10**(2): 173–203.

LEEDY, D. L. 1949. Ohio pheasant nesting surveys based on farmer interviews. Jour. Wildl. Mgt., **13**: 274–286.

RANDALL, P. E. 1939. Nesting habits and causes of nest mortality of the ring-neck pheasant. Penn. Game News. **10**: 6–7, 30.

TWINING, H., H. A. HJERSMAN, and W. MACGREGOR. 1948. Fertility of eggs of the ring-necked pheasant. Calif. Fish and Game. **34**(4): 209–216.

Accepted for publication June 12, 1951.

STUDIES IN CONTROL OF THE PRAIRIE MOLE *SCALOPUS AQUATICUS MACHRINUS* (RAFINESQUE)

Willard L. Henning

Biology Department, Arkansas College, Batesville, Ark.

This paper is a report of results of a series of tests that were conducted for control of the prairie mole in the vicinity of Columbus, Franklin County, Ohio. The work was sponsored by Charles A. Dambach, Chief, Ohio Division of Wildlife, and was made possible by the Ohio Cooperative Wildlife Research Unit, The Ohio State University, Columbus, Ohio.

In areas where mole damage is a problem the most satisfactory method for control seems to be eradication rather than repellence. The method of eradication that has been generally recommended is the use of traps (Silver and Moore, 1941). However, trapping may not be successful if the traps are not set properly. A simpler and more satisfactory method of destruction is needed.

Attempts have been made for many years to destroy moles by the use of poisons (Scheffer, 1910, Jones, 1948, and Bennett *et al.*, 1942). The materials used for killing moles may be classed as either fumigants or bait poisons. Newer insecticides which have been tested as tracking agents for control of rodents (Rudick, 1948) have also been suggested for control of moles.

During this investigation field tests were made of the effectiveness of newer insecticides, fumigants, commercial baits, and poison baits for destruction of the prairie mole. Tests were also made of these substances on moles placed in fenced plots each enclosure having an area of 200 square feet. Captive moles were also exposed to these substances. Tests were completed on 4 fumigants, 5 commercial baits, 7 poison baits, and 9 of the newer insecticides. Three of the insecticides were tested at two concentrations. Only the treatments involving the use of thallium-coated peanuts, strychine-dusted earthworms, and sodium fluoroacetate-treated earthworms resulted in a complete cessation of activity in field runways. Systems of mole runways on large golf courses were chosen as sites for conducting all except a few of the tests. Since the grass on these sites was mowed regularly, the reaction of the mole to the treatment was readily observed.

Thallium-coated Peanuts

The product tested consisted of 1% thallium sulphate, sold under the trade name "Tat Mo-go". It was used as a coating on raw Spanish peanuts.

The method of application was to deposit 3 or 4 of the thallium-coated peanuts in active runways on golf courses at intervals of a few feet. The holes were covered, and care was taken not to crush the tunnels at the sites of treatment. The term "active runway" refers to runways that had been tramped previously, and that were raised again as a result of recent burrowing activity. However, a simpler method for the determination of active usage of runways

is to punch holes in all runways at intervals of 3 or 4 feet, and observe which of these holes are filled or have been flanked by fresh burrows on the following day.

In the 4 treated runways, activity ceased 2 or 3 days after the baits were applied. One dead mole was recovered from the surface of the ground of one of the treated runways. This specimen showed no indication of external injury. No fresh activity was observed in areas adjacent to these runways a week after the one and only treatment was given.

A mole that had been captive for several months was given one half of a thallium-poisoned raw peanut with the usual quantity of daily food. Evidence indicated that the half peanut was almost entirely consumed. During the following days the amount of food eaten became gradually less, and the mole was found dead in 10 days.

Two moles were tested separately in fenced plots in an open field. Observations based on previous tests indicated that the plots were mole-proof. The poisoned peanuts were placed in established runways and were not exposed to the surface. Part of the peanuts were missing following each exposure. The mole first tested was killed accidentally 3 days after the baits were applied, and all burrowing activity ceased in the second plot 8 days after the application of the poisoned bait.

Untreated raw Spanish peanuts were ingested by 8 of 9 newly captured moles, and no harmful effects were observed.

Results of the above tests indicate that the prairie mole may be controlled by the application of thallium-coated raw peanuts in the runways.

If this method does prove equally effective after extensive open field tests are completed, it may be regarded as one of the most practical methods of control. This poison bait may be kept for an indefinite period of time. No preparation is required, such as is necessary for poisoned earthworms. The time required to treat a large area may be relatively small.

STRYCHNINE-EARTHWORMS

Strychnine sulphate was dusted on live earthworms from which the anterior segments had been removed to prevent their escape by burrowing. Worms four inches or more in length were cut in half, and two such treated baits were placed in active runways, at 4 or 6 foot intervals. The method described above was used for determining active runways.

Of the 6 systems of mole runways tested by this method, 5 were on a golf course, and one was in a lawn. Six applications of the poisoned earthworms were given the runway system of the lawn, whereas from one to three applications were given the runways of the golf course before activity ceased. It seems possible that more moles may have inhabited the runways treated on the lawn. Three of these tests were conducted during late August and early September, and three were conducted during the latter part of May.

A strychnine-dusted earthworm that was placed before a freshly captured mole was rejected. After being moistened with water, however, the worm was immediately consumed, and the mole died about 19 minutes later. As a check on the acceptance of strychnine-treated earthworms after lying in a mole tunnel several hours, two dusted

earthworms, and two dusted and moistened earthworms were kept in a mole tunnel for 9 hours before being tested on a second captive mole. No preference was observed for either of the treated baits by the mole.

Two moles in separate fenced plots were given strychnine-dusted earthworms. All burrowing activity ceased the day following the treatment, whereas activity continued in the plots in which no poisoned worms were placed.

The amount of strychnine sulphate dusted on the worms was not measured in the tests. When both heavily dusted and lightly dusted earthworms were placed before a captive mole no preference was observed. However, both the heavily treated and lightly sprinkled earthworms were only partly eaten when tested as dry bait.

Results indicate that the prairie mole can be eradicated completely by the use of strychnine-dusted portions of earthworms.

This method seems to be about as practical as any method tested during this investigation. Both strychnine sulphate and earthworms are available to the public, although strychnine must be handled with caution.

SODIUM FLUOROACETATE-EARTHWORMS

In these tests, earthworms were treated with a solution of 1080 or sodium fluoroacetate. This method was first developed by A. W. Moore and has been tested for mole control in the Pacific Northwest. Details of Moore's method are not available for publication, but it is described in Memorandum #139 issued to Field Personnel of the Division of Predator and Rodent Control, U. S. Fish and Wildlife Service, (1948).

The 1080-earthworm method was found to be effective when tested on active runways in the open field during June and November. Evidence indicated that 2 moles in fenced plots and one captive mole died following their exposure to earthworms treated with sodium fluoroacetate. Moles were provided in untreated plots during the tests in fenced plots. The 1080-earthworm method is not recommended to the general public since sodium fluoroacetate is extremely poisonous to higher animals.

It should be pointed out that the above methods, which were found to be effective in these tests and under these conditions, cannot be recommended as generally effective until extensive tests are conducted during all seasons of the year and throughout the various parts of the range of the prairie mole. The preliminary tests point to these methods as being the more promising ones of all those tested.

The methods that were tested and their results are listed in Tables 1, 2, 3, and 4.

The trade names of the prepared baits are as follows:

Arsenic trioxide and bait mixture—"Force's Mole Killer",
Ricine and bait mixture—"Mologen",
Strychnine and Canary grass—"Mouse-Mole Deth",
Strychnine and Hemp seeds—"Mole-Nots",
Thallium and peanuts—"Tat Mo-go".

The terms "partial control" or "partial repellence" indicate control or repellence in part, but not in all, of the tests conducted. Otherwise the term under "Results" is used to cover the results of all the tests. The number of

TABLE 1.—RESULTS OF INSECTICIDE TREATMENTS

Times Tested	Insecticides and Concentrations	Results
3	25% Aldrin wettable powder	Partial repellence (1)
3	12% gamma Benzene Hexachloride wettable powder	Partial repellence (2)
3	25% gamma Benzene Hexachloride wettable powder	No control
3	5% Chlordane dust	No control
3	50% Chlordane wettable powder	Partial repellence (1)
3	5% DDT dust	No control
3	50% DDT wettable powder	Partial repellence (2)
4	25% Dieldrin wettable powder	Partial repellence (3)
3	5% Heptachlor dust	No control
3	50% Heptachlor wettable powder	Partial repellence (1)
4	50% Methoxychlor wettable powder	No control
7	15% Parathion wettable powder	Repellence

TABLE 2.—RESULTS OF FUMIGANT TREATMENTS

Times Tested	Fumigants	Results
3	Chlorinated hydrocarbons-by-product	Partial control (1)
3	99% Chloropicrin	Repellence
4	42% Sodium cyanide	Repellence
3	Sulphur dioxide, Carbon monoxide, and Hydrogen sulphide	Partial control (1)

times control or repellence was observed is given by the number in parentheses, and results were negative in the remaining tests. The term "Control" is used to indicate a cessation of fresh activity in surface runways simultaneous with treatment of the runways, and no indications of fresh activity in the vicinity of the treated runways. If there were indications of burrowing activity in the vicinity of treated runways, or in areas adjoining them, during the time of treatment, the term "repellence" is used. In this paper the term "insecticide" is used with reference to certain organic compounds whose effectiveness in kill-

TABLE 3.—RESULTS OF TESTS OF COMMERCIAL BAITS

Times Tested	Commercial Baits	Results
3	5% Arsenic trioxide and bait mixture	Partial control (1)
3	0.3% Ricine and bait mixture	No control
3	0.5% Strychnine-Canary grass	No control
3	0.5% Strychnine-Hemp seeds	No control
4	1.0%Thallium-Peanuts	Complete control

TABLE 4.—RESULTS OF POISON BAIT TREATMENTS

Times Tested	Poison Baits	Results
3	0.5% Warfarin-Earthworms	Partial control (1)
3	5.0% Warfarin-Earthworms	No control
3	Red Squill extract (LD-50 of 200 mg./kg.)-Earthworms	No control
3	Red Squill powder (LD-50 of 500 mg./kg.)-Earthworms	No control
6	2½% Sodium fluoroacetate-Earthworms	Complete control
6	Strychnine-Earthworms	Complete control
3	4% Thallium-Earthworms	Partial control (2)

ing insects has been demonstrated during recent years. "Tracking agents" are toxic substances that are applied in the runways of animals or wherever they may be picked up on the feet and fur. During the process of removal, some of the material, presumably, may be taken into the mouth. "Fumigants" are toxic gaseous materials that are used for pest control. "Commercial baits" are prepared poison baits that have been sold commercially for mole control.

DISCUSSION OF RESULTS OF INEFFECTIVE POISONS

Insecticides, in general, have very noticeable odors, and it is not surprising that moles were repelled frequently by such agents. Repeated treatments may have the effect of killing the insects and other food organisms in the mole runways. Live captive moles exposed directly to the insecticides by tracking were unaffected except those exposed to Aldrin, Dieldrin, and Parathion. Death came in three or four hours after exposure to Parathion, and in from two to eight days to moles exposed to Aldrin and Dieldrin. It seems probable that Parathion was effective as a fumigant rather than as a tracking agent. In field tests, one mole which was found dead at one of the runways treated with Parathion, showed symptoms of diarrhea very similar to a laboratory animal that had been killed by Parathion. Even though activity ceased in four of the treated runways, fresh activity was noted in the vicinity in each instance.

A factor in the effectiveness of fumigants may be the strength and effectiveness of their odors. Probably the more promising fumigants, such as carbon monoxide and ethylene trichloride, are relatively odorless, and are lethal in very minute quantities. It was observed that moles frequently burrowed around runways treated with Chloropicrin. Fumigants should be applied close to the nest so that the toxic substances will reach the victim in lethal dosages. Very frequently it is difficult to apply fumigants in this manner, since nests are commonly under trees or along fence rows.

A satisfactory commercial bait must contain an imperishable product. It must be eaten by a high percentage of moles, and it should contain a toxin that, although relatively tasteless and odorless, is lethal in small dosages. In all tests conducted with the commercial baits, except thallium-coated peanuts, evidence indicated that all baits not containing peanuts were passed by. There is evidence of the presence of peanuts in "Force's Mole Killer". The other ingredients of this bait were not identified. An imperishable bait that is eaten by all moles is needed.

Earthworms poisoned with red squill were rejected by laboratory caged moles. This was probably due to the odor or taste. Warfarin is reported (Kreiger, 1949) as tasteless and odorless, but no suitable method was found for making it adhere to the earthworms in sufficient quantities. Probably, as for rat control, this toxin should be given in several consecutive doses for effective results. This may be difficult under field conditions, since moles frequently change the location of their runways. The thallium-treated earthworms were not accepted immediately by one captive mole, but a second mole ate one of the two treated worms placed before it, and this mole was found dead three days later. The results of the inconclusive field tests

with thallium-treated earthworms may have been due to rejection of such bait by the moles. In laboratory tests earthworms soaked in a solution of 4% thallium sulphate indicated a tendency to disintegrate, especially when the temperature was very high.

SUMMARY AND CONCLUSIONS

1. The author made tests of newer insecticides, fumigants, commercial baits, and poisoned earthworms for destruction of the prairie mole.

2. Results indicate that the prairie mole may be eradicated by the use of moistened earthworms which have been treated with strychnine sulphate, or with sodium fluoroacetate solution (1080). In open field tests earthworms treated with thallium sulphate were 66.6% effective in controlling moles. Earthworms that were treated with Warfarin and red squill were not efficient in controlling moles in the runways that were tested.

3. Treatment with raw Spanish peanuts coated with thallium sulphate was followed by a cessation of activity in all of the mole runways treated in the open field. This poison bait may be applied to large areas of infested runways with a relatively small expenditure of time. The method, if found effective, may be practical for persons inexperienced in the use of traps or other methods. Products that were sold locally for mole control which did not contain thallium sulphate as the poison and raw peanuts as the exclusive bait were not efficient in controlling moles in the runways tested.

4. As used by the experimenter, none of the fumigants tested was successful in bringing about a complete cessation of activity in more than 33% of the runway systems tested.

5. The application of newer insecticides to mole runways was followed by a continuance of burrowing activity in areas adjacent to the treated runways, or by no change in activity in treated runways.

6. On the basis of results of this investigation it is suggested that the strychnine-earthworm method, the 1080-earthworm method, and the thallium-peanut method be tested thoroughly in all parts of the range of the prairie mole, and during all seasons when testing is possible. An ideal poison for killing moles is one that is tasteless and odorless, and one that is extremely toxic to moles in small quantities. An ideal bait should be an imperishable food that is eaten by all moles.

LIST OF REFERENCES

BENNETT, S. H., KEARNS, H. G. H., LING, A. W., MORGAN, N. G., Investigations on the destruction of moles. Annual report, Agric. and Hort. Research Sta., Long Ashton, Bristol, Eng. pp. 51–55, 1942.

JONES, JOHN C. 1948. Mole control in the Eastern United States. Pests, **16**: 23–28.

KREIGER, CARL H. 1949. Comp 42-A New Anticoagulant as a Rodenticide. Pests and Their Control, **17** (5).

RUDICK, JACK. 1948. DDT Powder for Mouse Control. National Pest Control Association, Inc., Service Letter No. 513, Appendix No. 1, p. 1.

SCHEFFER, THEO. H. 1910. The common mole. Kansas Agric. Exp. Sta. Bull. #168.

SILVER, JAMES and MOORE, A. W. 1941. Mole Control. U. S. D. I., Wash., D. C. Conservation Bull. #16.

Accepted for publication Oct. 10, 1951.

TECHNIQUES USED TO INCREASE NESTING OF CANADA GEESE [1]

Charles F. Yocom

Zoology Department, State College of Washington, Pullman

Canada geese (*Branta canadensis moffitti*) breed in considerable numbers east of the Cascade Mountains along the Columbia, Snake, lower Palouse, and upper Okanogan rivers in Washington (Yocom, 1949 and 1951) (Hansen and Oliver, 1951). Most of the breeding areas are along rivers or in the scabland channels (Bretz, 1928) of the Columbia Plateau where tree growth is extremely limited or entirely absent. There is, however, a sizable breeding population of Canada geese along the Okanogan River near the international border between Tonasket and Oroville, Okanogan County, and a few pairs breed along the Similkameen River north of Palmer Lake, Okanogan County. Both of these river valleys are relatively broad and "U" shaped as a result of their glacial origin. The Okanogan River after flowing from Lake Osoyoos, British Columbia, meanders through its valley, thus creating islands and large bends which are heavily overgrown with an undercover of shrubs and herbs and an overstory of large *Populus trichocarpa* and *Salix* sp. Adjacent benchlands are in orchards or other agricultural crops and some of the valley floor has been cleared and is used for growing oats, wheat and other farm crops. Yearly high waters resulting from melting of snow in the surrounding mountains has tended to discourage agriculture in the lower parts of the valley. Ox-bow lakes which represent now disused segments of the river channel are also present south of Oroville, where at least 25 to 30 pairs of geese breed.

The valley of the Similkameen River, however, traverses through relatively unsettled country. Large cottonwoods are abundant along the river near the British Columbia-Washington boundary and an understory of shrubs is well developed. Land use in this area is restricted primarily to the raising of cattle.

Bradshaw (1930) relates a Canada goose nesting 20 ft. high in a tree in Alberta and Bernard (1947) cites evidence that Canada geese nested in trees near Cheney, Washington, in the early days. Hansen and Oliver (1951) found two pairs nesting in great blue heron nests, one 12 feet above the ground, on the islands in the Columbia River, but present records of Canada geese nesting in considerable numbers high in trees have not been recorded. In the north central part of Washington, however, geese take possession of deserted or active osprey nests which are generally near the top of large cottonwood trees (often dead snags). Nests of Canada geese made in osprey nests have been seen by the writer both in the Similkameen and Okanogan valleys in 1949

[1] This study was supported in part by the State College of Washington Research Fund. The author is indebted to Joe Parker, Steve Krousoff, Sam Gjerde and the Floyd Paynes for making and assisting with observations in the Okanogan and Similkameen valleys.

and 1950, and geese are known to have nested in this same manner for several years prior to these observations.

Plate 9 shows an osprey nest located near the top of an old cottonwood on the west bank of the Okanogan River about one mile north of the Floyd Payne Ranch which is located directly south of Oroville. This nest had been claimed by a pair of Canada geese and at the time the picture was taken, 7 April 1949, a goose was incubating. The female could be seen easily from a distance, but she flattened out and lowered her neck when the nest was approached. This nest was at least 55 feet from the ground. Another pair of geese nested in another osprey nest located in a cottonwood tree a short distance north of this nest site. Steve Krousoff and the writer estimated it to be nearly 90 feet from the ground.

ACTIVITIES OF THE OROVILLE SPORTSMEN'S ASSOCIATION

During the spring of 1944, F. P. Sprouse, Sam Gjerde and Joe Parker, all members of the Oroville Sportsmen's Association, observed Canada geese claim osprey nests located south of Oroville in old cottonwood trees on the George Knowell's farm. A recent fire had burned many of the old snags which contained osprey nests. Noting that several pairs of geese were attempting to claim one nest that remained available encouraged them to construct 18 basket-like nests out of willow twigs lined with straw and hay. They placed them in willow and cottonwood trees along the Okanogan River and around Horseshoe Lake. Twelve of these nests were used by Canada geese that spring.

In the early spring of 1945, they placed four more willow nests in trees. To save time and effort, they also retrieved two galvanized wash tubs from local dumps and put them in trees. After placing a tub in the top crotch, and nailing and wiring it securely between the branches, they cut off the top branches even with the tub so that a goose could easily approach the nest site (Plate 9). That spring nesting geese used each tub.

The first tubs were lined outside with tall grasses held in upright positions about the tubs with bailing wire to make them appear natural. When winds blew all of the grass away from the tubs, however, this did not apparently detract from their suitableness as nesting sites because geese nested in each of them.

In 1946 no new nests were made available to geese. In 1947 two additional tubs were placed in trees along the river. One of these was used by a pair of geese which brought off a brood. Two more tubs were located in trees and some of the old willow nests were repaired during the spring of 1948.

A new type of woven willow nest was constructed by Steve Krousoff in 1949 (Plate 10). Three of these were placed in the crowns of yellow pine (*Pinus ponderosa*) on Grubs Point on the east shore of Lake Osoyoos. Geese visited these nests but did not use them, possibly due to human disturbance. More nests were placed on the Floyd Payne ranch that same year and several of these were used. Some of the tubs were placed in lower crotches of large willows or on sloping tree trunks.

Fifty-three artificial nests were available for nesting geese in the spring of 1951. Parker and Krousoff counted eggs

PLATE 9. Left. An old osprey nest taken over by a pair of Canada geese. The female goose was incubating when this picture was taken. Note the well developed understory of shrubs along the river bank. Center. A tub well located in the top of a willow tree. Geese can approach the tub without difficulty since all branches are cut that would hinder an approach. Note the granite mountain sparsely covered with Douglas fir and yellow pine in the background. Right. A different type of nest made with willow branches and chicken wire used for a base. Wind had blown some of the nesting material from this nest which was used the year before.

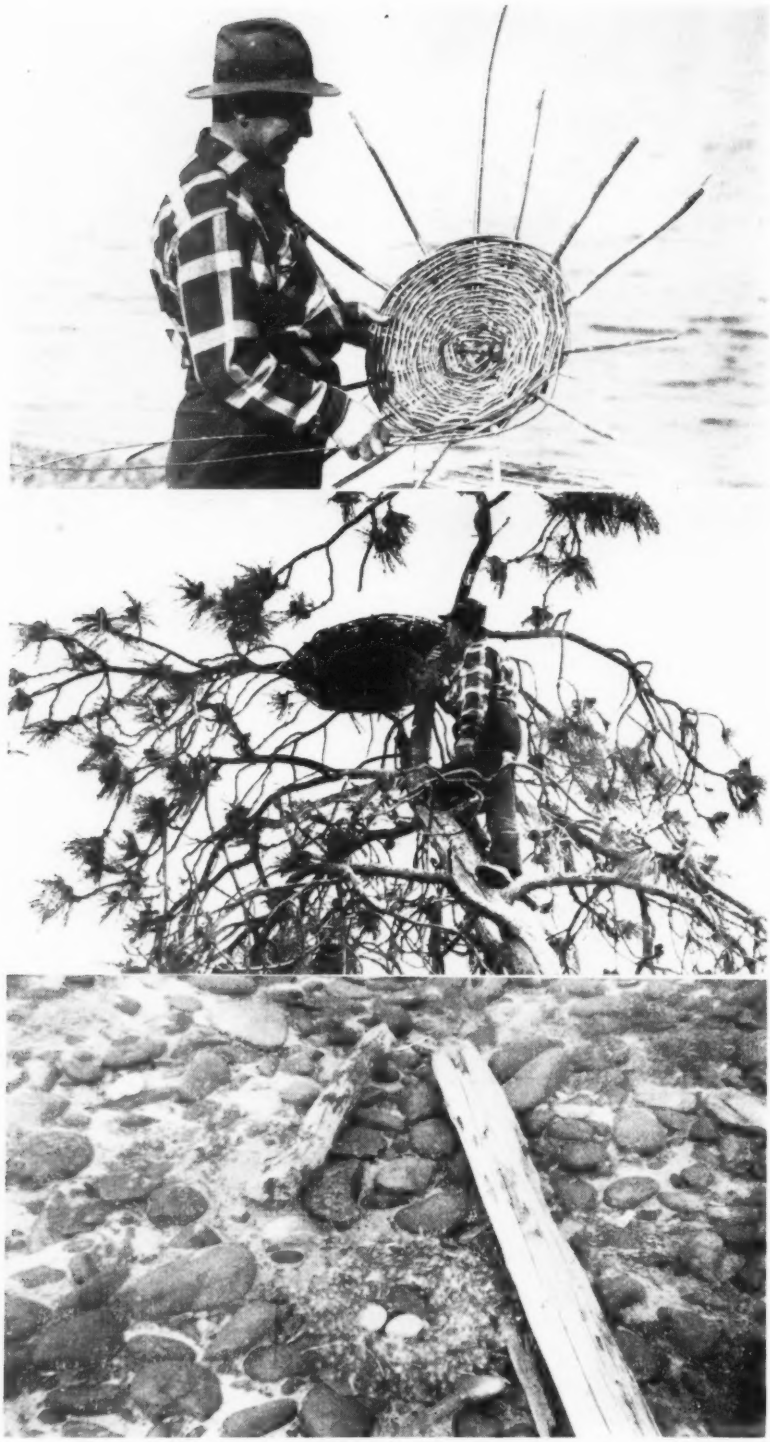


PLATE 10. Above. A detailed view of the weaving technique used in constructing a base for a goose nest. Note how the willow branches are crisscrossed. Center. Steve Krousoff inspecting one of his nests woven of willow. Geese visited this site several times but did not nest here probably due to human disturbance. Below. A Canada goose nest located near a log placed on an Island on the Snake River, Washington.

in 12 of these nest sites and geese were seen in several other artificial nests. Four pairs nested in the available osprey nests.

Several types of basket-like nests were constructed. One type (Plate 10) was constructed by using green willow to form a large outer loop and others bent in criss-cross fashion to form a bowl. Chicken wire netting was used to form a base for straw and hay. In others willow shoots were bent and wired to those criss-crossed to form a receptacle for hay and straw which was wired in all cases to the bowl of the nests. Cattails and grasses were tied and woven into the flat-like bowl of these nests to act as a base for the geese to nest on.

VALUE OF TREE NESTS

There is no doubt that the Oroville Sportsmen's Association has contributed considerably towards the welfare of nesting Canada geese in their vicinity. Geese that nest on the ground in that area are always in danger of floods destroying their nests before they hatch, dogs, and human molestation. Ospreys furnish only a limited number of available nests in trees for the geese. Reduction of ospreys limits the number of nests that are built yearly in the river valley. All people in this area should be aware of the association between the geese and the osprey and all possible encouragement should be given to the protection of the latter.

Goose nests in the Okanogan area average about seven eggs per nest (twelve clutches counted in 1951 averaged 6.9 eggs per clutch). Based on these counts, the sportsmen of Oroville have contributed towards the successful hatching of approximately the following number of goslings from nests placed in trees, if all but one egg hatched per nest:

1944 — 77 goslings
1945 — 125 "
1946 — 75 "
1947 — 110 "
1948 — 150 "
1951 — (82 eggs counted in 12 of 52 tub nests; 40 of these tubs were not inspected although geese used many of them—150+ goslings.)

These figures are based on observations made by Parker and Krousoff. This is an excellent example of what can be done for our wild game species by energetic sportsmen. Possibly these techniques could be used to an advantage in other areas.

There are conflicting accounts of how the goslings get out of these tree nests. Parker (personal letter) states that Hudlow of Oroville has seen adult geese take a gosling at a time from the nest in its beak and fly to the water. He also states that George Knowell has observed the adults push the young out of the nest. Others state that the young cling to the back of an adult as a means of getting to the ground.

In 1949, a rancher told Krousoff that he had observed the young geese "tumble" from the tree. More detailed observations are needed to clarify these points. Possibly all of the methods are used at times.

Investigations of tree-nesting ducks, however, show that the usual thing is for the downy young to reach the ground by jumping from the tree or box (Kortright, 1942).

TECHNIQUES USED ON ISLANDS ON THE SNAKE RIVER

Periodically high flood water occurs along the Snake River that inundates most of the natural islands in the river. At times large logs are left stranded on these islands as the water recedes, and at other times old logs stranded in the past are washed away and little driftwood remains. Geese nesting in this area show a preference for nest sites near logs or driftwood. The writer has found that islands can be made more attractive to geese by dragging logs and smaller pieces of driftwood towards the middle of these islands where there is a scarcity of such material. Plate 10 shows a nest which has been built near objects thus moved in. This technique could be used any place where geese nest on islands. Undoubtedly permanent nesting locations could be constructed on islands that are normally not completely flooded. A type of platform with built up sides placed on poles or posts might attract nesting geese.

LITERATURE CITED

BERNARD, ROBERT JAMES. 1947. A history of Turnbull National Wildlife Refuge near Cheney, Washington. M.A. Thesis in History, University of California Library, Berkeley, California (unpublished). 114 pp.

BRADSHAW, F. 1930. Unusual nesting sites. Canadian Field-Naturalist **44**(6): 149–150.

BRETZ, J. HARLAN. 1928. The channeled scablands of Eastern Washington. Geographical Review **18**: 446–477.

HANSEN, HENRY A. and WENDELL H. OLIVER. 1951. The status of resident Canada geese in south-central Washington, spring, 1950. The Murrelet **32**: 3–7.

KORTRIGHT, FRANCIS H. 1942. The ducks, geese and swans of North America. The American Wildlife Institute. Washington, D. C.

YOCOM, CHARLES F. 1949. A survey of waterfowl in eastern Washington in 1947. The Murrelet **30**: 46–52.

YOCOM, CHARLES F. 1951. Waterfowl and their food plants in Washington. University of Washington Press, Seattle, Washington.

Accepted for publication Sept. 13, 1951.

VARIATIONS IN TWO SPRING INDICES OF MALE RING-NECKED PHEASANT POPULATIONS[1]

Edward L. Kozicky

Iowa Cooperative Wildlife Research Unit, Department of Zoology and Entomology
Iowa State College, Ames, Iowa.

In the management of a game species, such as the ring-necked pheasant (*Phasianus colchicus*), it is necessary to develop, evaluate, and improve the census techniques used in determining the statewide status of the species. Bennett and Hendrickson (1938) first used the roadside census as an indicator of fall pheasant population trends. In spite of its statistical weakness on a monthly basis throughout the year for two routes in Montana (Fisher, *et al.*, 1947), the fall roadside census in an agricultural state such as Iowa does provide a reliable index of population levels when used over many routes on a statewide basis (Stiles and Hendrickson, 1946).

Kimball (1949) developed the crowing count of male pheasants into a useful technique as a spring index of population trends; that is, the method was comparable to a spring roadside census in costs and the coefficient of variation per mile over established routes in the spring was decidedly less (8.4 as compared to 40.0 percent).

In the spring of 1950, while comparing the crowing count for 10 stations to a known population, the investigator noted that the number of observed male pheasants along the roadside showed little variation from one morning to the next, whereas the number of hen pheasants indicated a higher degree of fluctuation. The variations observed in the roadside and crowing counts were checked, respectively, for 25 and 14 mornings in 1950 and 15 and 10 mornings in 1951.

The 10-mile route utilized for the study included the section-line roads around sections 13, 14, and 23, Eden Township, Winnebago County, which is part of the Winnebago Pheasant Research Area. The topography is rolling, and the area lies entirely within the Wisconsin drift soil area. The average 160-acre farm on the area in 1950 had 53 acres in corn; 45 acres in small grains, mostly oats; 22 acres in soybeans; 15 acres in hay; 14 acres in pasture; and 11 acres in miscellaneous use, such as farm groves, gardens, hog lots, etc. During the spring period, especially after the oat crop is seeded, vegetative cover is at a minimum. This condition facilitates the observation of pheasants.

[1] Journal Paper No. J-2018, Proj. No. 497, Iowa Agricultural Experiment Station, Ames, Iowa. U. S. Fish and Wildlife Service, Iowa State College, Iowa State Conservation Commission, and the Wildlife Management Institute cooperating.

The writer is indebted to Carroll Grondahl, Fellow, Iowa Cooperative Wildlife Research Unit, for the 1951 data. Professor Paul G. Homeyer of the Iowa State College Statistical Laboratory was more than generous with his aid in the statistical analyses of the data. Thanks are also expressed to Dr. G. O. Hendrickson, Department of Zoology and Entomology, Iowa State College, for his encouragement.

In 1950, pheasant populations were estimated by direct census to be about 50 birds per section with an observed sex ratio of 34 males to 100 females; in 1951, 60 birds per section with an observed sex ratio of 40 males to 100 females.

FIELD TECHNIQUES

The crowing count was taken according to the method described by Kimball (1949). Instead of a linear route, however, a circuitous, 10-mile route was established in order to evaluate the effect of time on the crowing count. Stations One and Two were the same as Nine and Ten, respectively, but the counts were taken about 45 minutes apart at each station. The count was started about 35 minutes before sunrise and was completed in about 50 minutes. As speed between stations was essential, no records were maintained on the pheasants observed along the roadside.

The roadside count was similar to the technique employed by Bennett and Hendrickson (1938) for their fall census. Only one observer was used throughout the counts, and records were maintained as to the total males and females observed for each mile. Starting about 15 minutes after sunrise, the roadside count was conducted from a car driven at a speed of 10 to 15 miles per hour over the same route used for the crowing count. About the same length of time (50 minutes) was necessary for either the crowing or roadside counts. If identification of the sex of a pheasant was doubtful, the car was stopped and a 7 x 35 binocular was used to aid in the determination of sex, but was not used to find pheasants. No attention was given to the location of males that were observed on previous mornings nor to the width of the strip of observation. The effect of time in relationship to sunrise on the roadside count was not checked.

In both 1950 and 1951, spring planting of oats was about 75 percent completed before either census was inaugurated. The stage of this agricultural activity may influence the roadside count in subsequent years.

Notes were maintained on weather factors at the beginning and end of the two census methods. Wind velocity was measured with a windmill-type, hand anemometer, which was held about five feet above the ground. Air temperature, to the nearest degree Fahrenheit, and cloudiness, based on a 0–10 overcast, were noted. Dew was observed as either present or absent by walking through the vegetation and checking for the presence of moisture. Precipitation was recorded as to type and intensity.

The starting date for both census methods was governed by pheasant crowing intensity. When it was determined that pheasant crowing intensity had reached a plateau by only observing minor fluctuations in the daily mean for the 10-mile route (Kimball, 1949), the counts were begun.

In 1950 and 1951, the month of May, especially the second and third weeks, appeared to be the most suitable time to conduct the two counts. After the first week of June the growth of vegetation in road ditches and hay and oats fields and the waning of breeding activities undoubtedly influenced the roadside count.

PHEASANT CROWING COUNT

In 1950, a higher coefficient of varia-

tion per mile (19.3 percent) was observed in the crowing count than in 1951 (7.6 percent) or in Kimball's (1949) data for several routes (8.4 percent) in South Dakota and Minnesota (Fig. 1 and 2). Undoubtedly, the high mean count of 54.7 pheasant crows per station on May 3, 1950, was important in increasing the variability of the census. No explanation of this high count was

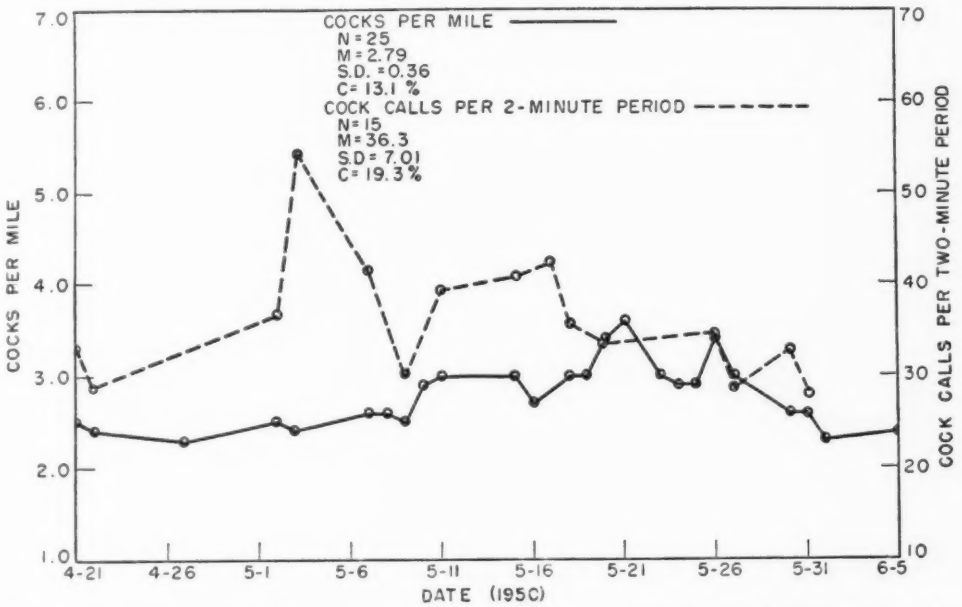


FIG. 1. Male ring-necked pheasant crowing and roadside counts, Winnebago County, Iowa, 1950.

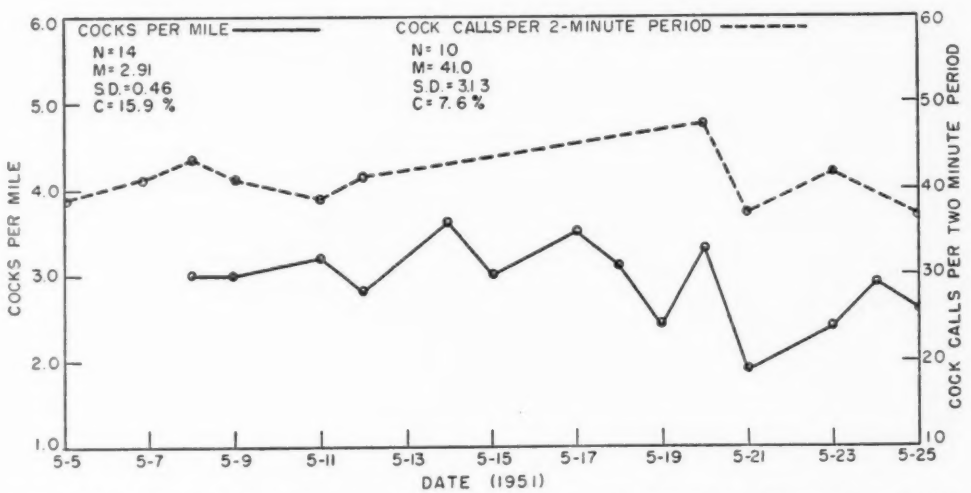


FIG. 2. Male ring-necked pheasant crowing and roadside counts, Winnebago County, Iowa, 1951.

apparent nor was such a large deviation from the mean recorded for any one morning in 1951.

No relationships were found between the effect of temperature, dew, and cloud coverage and the variation in the crowing counts for the 1950 data.

Wind velocity, however, influenced the crowing count (Table 1). The mean crowing count for the 10 stations showed a decrease of about 15 pheasant crows per station when the wind increased from 8 to 10 miles per hour. In 1950 only 15 of 27 mornings were encountered in which the wind velocity remained below eight miles per hour. This is in contrast to the roadside count in which weather conditions were suitable on 25 of 27 mornings. Similarly, in 1951, the wind velocity was favorable for the crowing count on only 10 of 19 mornings, whereas the roadside count was completed on 14 of 17 mornings. Wind velocities of more than eight miles

TABLE 1.—ANALYSIS OF SOME PHYSICAL FACTORS AND THEIR INFLUENCE ON THE PHEASANT CROWING COUNT AND SPRING ROADSIDE COUNT, WINNEBAGO AREA, IOWA, 1950

Type of Census	Physical Factor	Analysis	No. of Days	Mean	Standard Deviation	Coefficient of Variation (percent)	F Value
Crowing Count	Cloud Coverage	Partial (0–5)	8	34.0	4.47	13.1	1.86
		Complete (6–10)	7	38.8	8.78	22.6	
Roadside Count	Cloud Coverage	Partial (0–5)	11	2.8	0.35	12.5	0.06
		Complete (6–10)	14	2.8	0.39	13.9	
Crowing Count	Temperature	<40°F.	7	37.0	4.55	12.3	0.14
		>40°F.	8	35.6	8.89	25.0	
Roadside Count	Temperature	<40°F.	10	2.7	0.27	10.1	1.34
		>40°F.	15	2.8	0.40	14.0	
Crowing Count	Dew	Absent	5	37.5	10.00	26.7	0.41
		Present	10	35.1	4.59	13.1	
Roadside Count	Dew	Absent	12	2.6	0.27	10.4	6.63*
		Present	13	2.9	0.36	12.2	
Crowing Count	Wind Velocity	<8.0 m.p.h.	15	36.3	7.01	19.3	25.08**
		>8.0 m.p.h.	6	18.2	8.65	47.6	
Roadside Count	Wind Velocity	<8.0 m.p.h.	13	2.8	0.49	15.8	0.512
		>8.0 m.p.h.	12	2.7	0.25	9.1	

* Significant at the .05 level.
** Significant at the .01 level.

per hour precluded any analysis of the effect of snow and rain on the crowing count.

A definite decline was found in the crowing count at the same station from about 35 minutes before to 10 minutes after sunrise. The mean crowing count at station one for 12 mornings was 43.0, and for the same mornings but 45 minutes later, 27.5; at station two, 45.0 and 30.0. An analysis of variance (Table 2) in which the interaction of time and days is used as an estimate of the true error shows that the effect of time in relationship to sunrise on the crowing count is statistically significant at the one percent level. This decrease in crowing activity is also depicted by plotting separate means for the ten different stations (Fig. 3).

After the importance of time on crowing count was determined from the mean count at Stations One and Two and Nine and Ten, a linear relationship was assumed between crowing count and time. The means for the various stations were adjusted to eliminate the influence of time and the adjusted variations in the crowing count were taken to represent station effect. An analysis of variance of these data (Table 2) was made to determine the statistical importance

TABLE 2.—SUMMARIZATION OF THE MODELS FOR THE ANALYSES OF VARIANCE USED IN ANALYZING THE COMPONENTS OF VARIATION FOR THE SPRING PHEASANT CROWING AND ROADSIDE COUNTS

Effect of Time on Crowing Count*

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Values
Stations (S)	1	60.75	60.75	
Time (T)	1	2,790.75	2,790.75	489.00**
Days (D)	11	3,026.75	275.16	
T x D	11	627.75	57.07	
S x T	1	0.75	0.75	
S x D	11	397.75	36.16	
S x T x D	11	402.75	36.61	
Total	47	7,307.25		

Adjusted Crowing Count*

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Values
Stations (S)	7	639.20	91.31	1.60
Days (D)	14	5,675.92	405.42	7.11**
S x D (Error)	98	5,588.75	57.03	
Total	119	11,903.87		

Roadside Count*

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Values
Stations (S)	9	160.30	17.81	8.27**
Days (D)	21	26.33	1.25	0.58
S x D (Error)	189	406.80	2.15	
Total	219	593.43		

* Days were assumed to be a random variable.
** Significant at the .01 level.

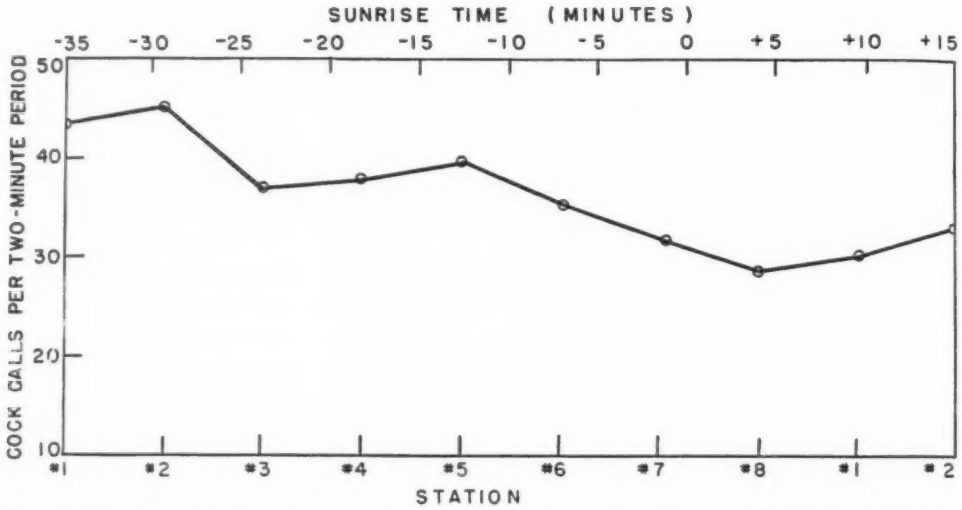


FIG. 3. The effect of time on the male ring-necked pheasant crowing count, Winnebago County, Iowa, 1950.

of the number of days and stations. The differences in crowing counts among stations were not statistically significant at the five percent level, while the difference among days was statistically significant at the one percent level. Biologically, this means that days had a larger effect on variation in crowing counts than did stations. If the crowing count was high or low for the first station, it usually remained consistently high or low for the other nine stations on any one morning.

Statistical analysis [2] of the adjusted crowing count data for 1950 revealed that nine random days were necessary to obtain a mean which would be expected to be within 10 percent of the assumed true mean, 43, with 95 percent confidence. This demonstrates the importance of repeating the crowing count on a given route when the variation is as high as it was in 1950.

[2] Variance among days for the mean of 10 stations per day is 405.42 (Table 2) ÷ 10 = 40.542. Variance of the mean of k random days of the mean for 10 stations is 40.542 ÷ k. Assuming a true mean of 43 calls per station and a true variance among days of 405.42, a standard error of the mean of 2.15 or less is required to obtain a sample estimate within 10 percent of the true mean with a 95 percent confidence. Therefore, $k = 40.542 \div (2.15)^2 =$ about 9 days.

ROADSIDE COUNT

The coefficient of variation for the male as compared to the female roadside count was rather consistent and low for both 1950 and 1951 (Fig. 1 and 2). In 1950, the coefficient of variation for the mean number of females observed per mile on the 25 mornings was 34.8 percent; in 1951, for 15 mornings, 29.4 percent. This high percentage of variability is also reflected when both male and female counts are combined (Table 3).

An analysis of the influence of dew, wind velocity, cloud coverage, and temperature was made of the roadside

TABLE 3.—THE RING-NECKED PHEASANT ROADSIDE COUNT DATA FOR A 10-MILE ROUTE, WINNEBAGO COUNTY, IOWA

	Date	No. of Days	Mean (Birds per mile)	Standard Deviation	Coefficient of Variation (percent)
Male	April 21–June 5, 1950	25	2.79	0.36	13.1
	May 8–25, 1951	14	2.91	0.46	15.9
Female	April 21–June 5, 1950	25	3.79	1.32	34.8
	May 8–25, 1951	14	3.80	1.12	29.4
Male and Female	April 21–June 5, 1950	25	6.6	1.39	21.2
	May 8–25, 1951	14	6.7	1.29	19.3

count (Table 1). The effect of the presence or absence of dew on the mean of the roadside count was the only one of the physical factors that was statistically significant ($F = 6.63$, .05 level = 4.32 for 1 and 23 d.f.). This was also found by Fisher, *et al.* (1947) in their analysis of the roadside census. If only the 12 mornings with dew were considered for analysis in the 1950 data, the percentage coefficient of variation was only 10.4 percent, as compared to 13.1 percent for the combined 25 mornings. Therefore, it may be advisable to select only those mornings in which dew is present. Fog was encountered on one morning in 1950 and eliminated the possibility of a roadside count, whereas the fog did not influence the crowing count. Snow and rain reduced the roadside count from a mean of 2.8 cocks per mile to 1.4 and 1.5, respectively. Wind velocities up to 17 miles per hour did not apparently influence the roadside count.

In analyzing the station to station variation in the two counts, the importance of the number of stations in stabilizing the mean for any given day was evident. On several mornings in 1950 the comparatively stable mean for the 10-mile route depended on the results of the last mile, but no seasonal consistency was noted in the roadside counts for any given mile. The data from the 1950 roadside census was segregated for each individual station (mile) and an analysis of the variance (Table 2) indicated that station effect was significant at the one percent level. This indicates that the minimum number of stations for the roadside count probably should be a ten-mile route. Perhaps the higher coefficient of variation in 1951 could have been avoided by a 15-mile route. The variation associated with the number of days, in contrast to the crowing count census, in the analysis of variance was not statistically significant at the five percent level. Statistical calculation [3] of the 1950 data

[3] Variance among days for the mean of 10 stations per day is 1.2539 (Table 2) ÷ 10 = 0.12539. Variance of the mean of k random days of the mean for 10 stations is 1.2539 ÷ k. Assuming a true mean of 2.91 cocks per mile and a true variance among days of 1.2539, a standard error of the mean of 0.146 or less is required to obtain a sample estimate within 10 percent of the true mean with a 95 percent confidence. Therefore, $k = 0.12539 \div (0.146)^2$ = about 6 days.

indicated that six random runs of the route were necessary to obtain a mean which would be expected to be within 10 percent of the assumed true mean, 2.8 cocks per mile, with 95 percent confidence. Here again, the importance of replicating a count on any one route is stressed if the count is to be used as an annual indicator of the trend in the male pheasant population.

DISCUSSION

The spring roadside count of males shows promise as an index to pheasant populations when used in conjunction with observed sex ratios. The roadside count was not influenced by wind velocities up to 17 miles per hour, whereas the crowing count was biased by wind velocities of more than 8 miles per hour. The presence or absence of dew does affect the roadside count to some extent but not the crowing count. Time of day influences the crowing count; therefore, it is important to start the annual crowing count at approximately the same time in relationship to sunrise for estimates of annual trends in population on any given route.

There is need for refinement in both techniques under different physical and biological conditions (Taber, 1949). Correction factors may be determined for time in relationship to sunrise on the crowing count and, likewise, dew fall on the roadside count.

The coefficient of variation for both census methods apparently increases with lower counts. In 1951, Glen Sanderson, Biologist, Iowa State Conservation Commission, had a mean of 9.1 pheasant crows per station for 14 mornings on a 10-mile route in east-central Iowa with a coefficient of variation of 33.4 percent. On the same route, the mean male pheasant count per mile was 0.36 for six mornings with a coefficient of variation of 76.5 percent.

In the analysis of variance employed in this paper it was necessary to assume that the days of observations were selected at random throughout the period of maximum crowing and that the interaction of station and days was an estimate of sampling error. As it is not possible to replicate the route on another area with the same pheasant population, these assumptions are essential for the statistical analysis of the data. Also, the days on which the two censuses were conducted were assumed to be a random variable.

SUMMARY

1. Data on the variability of the crowing count and roadside count of male ring-necked pheasants are presented for a 10-mile route in Iowa for 1950 and 1951.

2. In 1950, the coefficient of variation per station for the crowing count for 15 mornings was 19.3 percent; in 1951, for 10 mornings, 7.6 percent.

3. In 1950, the coefficient of variation for the roadside count per mile for 25 mornings was 13.1 percent; in 1951, for 14 mornings 15.9 percent.

4. Wind velocities in excess of eight miles per hour decreased the crowing count mean.

5. The presence or absence of dew significantly affected the mean roadside count. Notations as to the presence or absence of dew should be made.

6. No statistical significant difference for either the crowing or roadside counts was found in the means when the temperature was less or more than 40 de-

grees F. or when cloud coverage was partial (0–5) or complete (6–10).

7. A significant decrease was observed in the mean crowing counts obtained at two stations at 45-minute intervals. Therefore, it is important to commence annual crowing count censuses at about the same time in relationship to sunrise.

8. Analysis of variance showed that in the crowing count the variance observed among days was statistically significant at the one percent level, whereas the variance observed among stations was not.

9. The variability associated with the number of stations in the analysis of variance for the roadside count was found to be statistically significant at the one percent level. This is in contrast to the crowing count and indicates that probably a 10-mile route is the minimum length.

10. An analysis of the 1950 data showed that approximately nine random, replicated counts over the 10-mile route would be necessary to obtain a sample mean for the crowing count which would be within 10 percent of the assumed true mean, 43, with a 95 percent confidence; approximately six random, replicated counts, for the roadside count. This illustrates the importance of replication in order to obtain a mean that may indicate trends in population for any one route.

11. The observed female pheasants revealed a high coefficient of variation in roadside counts, 34.8 percent per mile in 1950 and 29.4 percent per mile in 1951.

12. More studies are needed on the adequacy of the roadside and crowing counts in different types of terrain and vegetative cover and at various pheasant population levels.

13. Indications are that both census methods have higher coefficients of variation in regions with lower counts.

LITERATURE CITED

BENNETT, LOGAN J. and GEORGE O. HENDRICKSON. 1938. Censusing the ring-neck pheasant in Iowa. Trans. N. A. Wildl. Conf., **3**: 719–723.

FISHER, HARVEY I., ROBERT W. HIATT, and WILLIAM BERGESON. 1947. The validity of the roadside census as applied to pheasants. Jour. Wildl. Mgt., **11**: 205–226.

KIMBALL, JAMES W. 1949. The crowing count pheasant census. Jour. Wildl. Mgt., **13**: 101–120.

STILES, BRUCE F. and GEORGE O. HENDRICKSON. 1946. Ten years of roadside pheasant censuses in Iowa. Jour. Wildl. Mgt., **10**: 277–280.

TABER, RICHARD D. 1949. Observations on the breeding behavior of the ring-necked pheasant. The Condor **51**(4): 153–175.

Accepted for publication Nov. 9, 1951.

A TRAP AND TECHNIQUE FOR THE CAPTURE OF DIVING WATERFOWL

I. McT. Cowan and James Hatter

University of British Columbia, Vancouver, B.C.

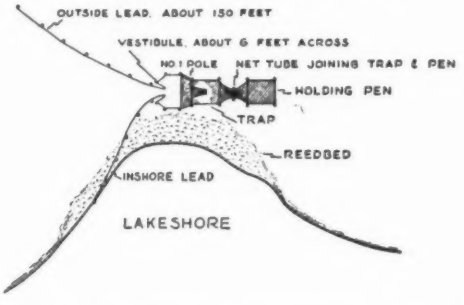
In 1948 the British Columbia Provincial Game Commission and the University of British Columbia, Department of Zoology, instituted a study of the waterfowl nesting populations of the Province. A large proportion of the waterfowl nesting here are diving ducks and inasmuch as relatively little work of this kind had been done on these species elsewhere, it was decided to concentrate on them. This involved the development of techniques and equipment for catching the birds in deep-water lakes. From the beginning the birds taken for banding have been broods with their parents and flightless adults captured during the moulting period. Baited traps proved useless for the task and modifications of the existing drive-trapping techniques were resorted to.

Diving duck populations on the nesting grounds are seldom as concentrated or numerous as are those of pond ducks and most of the trapping has had to be carried out on pot-holes bearing 50 birds or less. One of the first essentials of the technique, therefore, has been mobility.

Our basic banding unit has consisted of a 3-man crew with a 3/4 ton G.M.C. truck. A special carrier on the truck box carries 2 canoes; beneath the canoes are packed the collapsed trap units, while within the truck the camp equipment, nets, poles and a light, sturdy, 8 ft. moulded plywood dingy complete the equipment. With this crew and outfit we have been able to capture and band a large part of the waterfowl populations on lakes as much as 2 miles long provided that they are relatively narrow. Larger lakes, especially those half a mile or more in width, require more boats for a successful drive.

The trap consists of a pair of leads and from one to several trap and holding units. The leads are set up as the arms of a V and the trap units attached at the apex. The general design is illustrated in Fig. 1. The lakes are often deep and to obtain leads of the required length it is frequently necessary to operate in water 12 ft. or more in depth. The abundance of lodgepole pine in the banding area provided a satisfactory source of long slender poles and we have used these. Under other circumstances jointed aluminum poles capable of being assembled into various lengths to 20 ± ft. would be useful.

FIGURE I. DIAGRAMMATIC TRAP SET UP

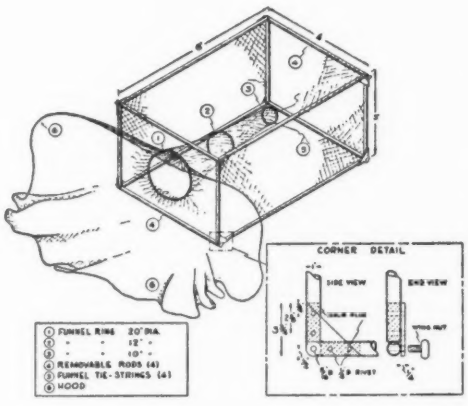


The entire trap is constructed of used anchovy seine net. This is stout fish net

of 3/4 inch stretched mesh in 8 ft. and 10 ft. widths. Single lengths are up to 150 ft. It is essential in driving the diving ducks that the lead nets reach the bottom of the lake. Usually one width of net is sufficient but in deep lakes we have joined two to make a 16 ft. net.

The trap unit proper consists of a rectangular framework of 1″ aluminum pipe 6 ft. long, 4 ft. wide and 3 ft. high. This is assembled so that two frames 6 ft. by 3 ft. are joined by 4 removable rods (Fig. 2). This trap frame is covered with net stretched tight and lashed on. At the front a funnel entrance

FIGURE 2 DIAGRAM OF TRAP UNIT



3 ft. long is supported by 3 stout wire hoops. In front of this a hood or extension of the funnel is attached. This spreads out to the full width of the net and is used for attaching the trap to the vestibule. At the other end of the trap is attached a tube of net that can be tied shut. It permits ingress to the trap or is used for joining the trap to the holding pen or other unit to accommodate a larger catch. In practice we use a second trap unit, without the funnel, as a holding pen for catches up to 200 birds. This has each end in the form of a 4 ft. tube of net. For still larger catches we attach a tube of net 40 ft. long to the back of the second unit and can run this ashore into a holding pen on land.

The trap is set up by placing the poles for the vestibule and leads. These should project about 4 ft. from the water. Beginning at the back of the vestibule (#1) the net is hung on each lead and fastened as needed. If a wind is blowing the net should be tied at the waterline, otherwise this is not necessary. The traps are then placed and supported with poles at each corner of each unit and as required for connecting funnels, *etc.* The trap should be so placed that the funnel entrance is submerged for half its height. The trap hood is joined to the vestibule using two pieces of stiff copper wire threaded in and out. These are so arranged that when the trap is full the wires can be quickly drawn and the trap hood closed and the trap freed. Trap units are joined similarly but we plan to provide the end of each tube with a stiff hoop that can be tied to its counterpart. This will permit more rapid assembly and take down. The latter is particularly urgent to prevent the drowning of younger ducklings once the trap is full.

The entire trap can be operated in water too deep for wading but we try to place it so that the trap unit and holding unit at least can be reached by men in armpit waders.

Before the drive is commenced a final inspection should be made to make sure that no holes exist anywhere below water and that the bottom of the vestibule is completely covered with

net, and that the lead nets are on bottom with no passages beneath them. We have thought of using a light leadline to hold the bottom down but this has not yet been necessary.

TRAP PLACEMENT

The placement of the trap is an important consideration. In our experience diving ducks cannot be successfully driven through water choked with algae or pondweeds. The entire trap and the water leading to it must be free of such obstruction. Furthermore, they cannot be driven into a trap backed against a reed bed or other obstruction. Upon looking into the trap from the entrance clear water must show behind. If other requirements dictate the placement on a reedy point, a lane must be slashed through the reeds to give an unobstructed vista of open water. Success is unlikely if the trap is so placed that one has to drive the ducks from a larger, deeper section of the lake into a trap backed against a smaller shallower part of the lake. Three typical sites for successful traps are shown in Figures 3, 4 and 5. Water depth in the trap should not be less than 18″.

In the late summer when many almost flightless birds may be included in the drive, a downwind drive is preferable and the trap should be placed with this in mind. However, this is secondary to the other considerations discussed. The physical situation is paramount in importance.

In some instances the ducks appear to prefer a certain portion of the lake and if they are driven from this section and then back toward it they may enter the trap more readily. This was obviously the case on Westwick Lake (Fig. 3), where the birds were driven from the larger portion of the lake into the smaller one before the trap was erected. A considerable number of grebes entered the trap before the drive and it was apparent that the ducks also were restless and ready to return to the portion of the lake from which they had been driven.

FIGURE 3 WESTWICK LAKE

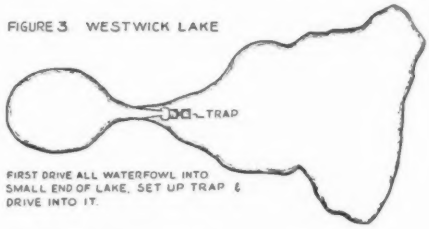


FIGURE 4 BRIGADE LAKE

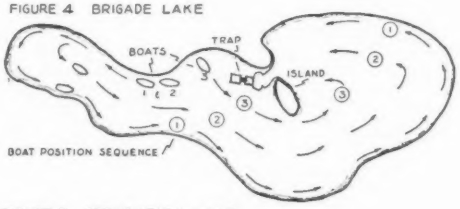
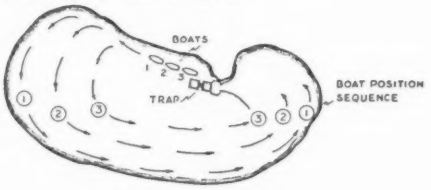


FIGURE 5 SEPARATION LAKE



Pot-holes so small that setting up the trap greatly disturbs the birds cannot be treated by the methods described.

DRIVE TECHNIQUE

The techniques of driving vary with the species of waterfowl involved and the circumstances of the particular situation. Unlike the conventional drives of pond ducks, the birds being driven are in view all the time, and the drive can be modified as necessary.

One complication is the different

swimming speeds of the different species of ducks. Canvasbacks are rapid swimmers and are highly nervous. On many lakes we have found it best to drive them separately from the other species. Buffleheads are slow swimmers, very tame, and the females are most antagonistic to one another. It has often been necessary to drive bufflehead broods into the trap separately. Barrow's goldeneye, lesser scaup and redhead are easy to drive and offer few problems.

The directions of drive in three different circumstances are shown on Figures 3 to 5. The positions of boats at a given moment are shown by numbered circles; the direction and path of movement by arrows. Note that the boats are so placed as to move the ducks against the shore away from the trap and then along it toward the trap. The position off the end of the net is probably the most important of all and should be manned by an experienced operator. One man should act as drive chief and direct the movements of the participating boats.

The drive should be accomplished with the least possible noise, bearing in mind that a mildly disturbed duck with her brood will keep on the surface whereas if she is frightened she will either fly or dive. In either case you will probably catch none of her brood. Drivers will quickly learn the behaviour of each species that betrays the degree of alarm and probable consequent action and will learn when to slow the drive or back off. The direction of movement of boats with respect to the movement of ducks to accomplish directed driving is important but will be quickly learned by an observant operator.

Once the birds are inside the arms of the leads some may dive and attempt to pass under the net. Flightless adults will almost always do this. Failing, however, they will soon surface and can then be urged into the trap. At the completion of a drive, to reduce drowning losses we quickly detach the trap and the pen, attempting to divide the birds between the two, and carry each ashore. We then remove the birds into open-mesh potato sacks, about 12 birds per sack. Sorting by species and age is done at this time so that young ducklings are not exposed to trampling by the larger birds. In the sacks the birds are warm and quiet and can be released in good condition.

Using this technique we have been successful in banding almost 5,000 Barrow's goldeneye, 700 bufflehead, 1,700 lesser scaup and smaller numbers of the scarcer or more elusive diving ducks. White-winged scoters and ruddy ducks have proven most difficult of all species to drive, but even these along with coots, horned, eared and Holboell grebes have been taken in considerable numbers.

Accepted for publication Nov. 9, 1951.

UPLAND FARMING AS A METHOD OF SUPPLEMENTING THE NATURAL WATERFOWL FOOD SUPPLY IN THE SOUTHEAST

Thomas Z. Atkeson and Lawrence S. Givens

Box 1643, Decatur, Alabama

The southeastern states are the wintering grounds of a large part of our continental waterfowl supply. The rapid expansion of population, agriculture, and industry have limited the once generous supply of natural foods and made a supplemental supply necessary or desirable in many localities. Upland farming furnishes one means of increasing this food supply.

The United States Fish and Wildlife Service has relied on upland farming to supplement waterfowl food on some of its southeastern refuges for more than a decade. This is particularly important on multiple-purpose, power and flood control reservoirs, where extreme fluctuation prevents natural food production. Farming is the basic management tool used on public shooting areas managed by several of the southeastern states, and on a number of private or club-owned hunting preserves. Background material for this paper has been gathered from various southeastern refuges managed by the U. S. Fish and Wildlife Service, notably from the Wheeler Refuge in Alabama, the Tennessee and Reelfoot Refuges in Tennessee, the Santee Refuge in South Carolina, and the Kentucky Woodlands Refuge in Kentucky. Some material has come from state-managed public-shooting grounds located in the Tennessee River valley. Shore-line plantings of upland crops and farming in dewatered areas are management tools in local use in the southeast, but are not considered within the scope of this paper.

The success that has attended upland farming as a management tool has been spectacular in many cases. Through this means, large concentrations of geese have been brought into areas where they were once rare or absent. Duck usage, limited by natural food shortage, has increased as much as several hundred percent when farm crops were used to augment this supply. It should be remembered, however, that only mallards, black ducks, and pintails will make significant use of unflooded upland fields. Even with these species, those following the Mississippi flyway use fields much more readily than do those on the southeastern part of the Atlantic Coast, and show marked local field and food preferences. Gradual "education" of the birds to use uplands and to use certain crops is sometimes necessary and possible. Canada, blue, and snow geese will feed on uplands more readily than will ducks, but geese also show striking local food preferences.

Location of Fields and Methods of Management

Upland farming can be used as a management tool wherever agricultural land in reasonable proximity to a water area is available to the managing agencies. Fields marginal to the water are desirable but are not always necessary, since waterfowl will often move several

miles inland to feed. Islands and peninsulas are ideal. In general, fields should be large and free of brush clumps, hedge rows, and similar cover. Brushy screens separating fields from water are undesirable. Since an accumulation of grass and weed growth will provide predator cover and discourage waterfowl use, crops should be kept clean cultivated.

Two management methods are possible: farming with the personnel of the managing agency, and farming on a share basis through rental to local farmers. The first method has the advantage of furnishing the maximum amount of food, but is expensive, requiring considerable machinery and labor. The second method—share rental—will make less food available, but can be carried on at a very low cost. It has the added advantage of utilizing the practical experience of local farmers and helps support the local rural economy.

The objective of upland farming for waterfowl usage is to furnish mature grain and seed for both wintering ducks and geese, and green browse for geese. The following have been found to be the most practical crops in most localities to serve these purposes:

Grain and Seed Crops

Corn, generally speaking, is one of the most desirable of all upland crops. It is preferred in most localities by both ducks and geese. It has the advantage of heavy production and will last through winter months with little deterioration. Waterfowl show little preference between the varieties. Hard-kernel varieties are less subject to rot, and hybrids are generally preferable to open pollinated varieties due to their greater production and shorter growing season.

Peanuts are eagerly taken by both ducks and geese, and are an excellent crop wherever soils are light and sandy and competition is not too serious. Running peanuts are preferred to the Spanish varieties due to their heavier production and ability to withstand winter rain without excessive rotting and sprouting.

The grain sorghums are good waterfowl-food crops. They have the advantage of heavy production and a short growing season. However, they are subject to small-bird and insect damage, and the seed deteriorates rapidly during rainy weather. While all varieties of grain sorghum are subject to good waterfowl use, the low-growing types of milo-maize are generally most desirable.

Rice requires highly specialized irrigation, soil conditions, and farming technique, but where it can be used, it furnishes one of the best waterfowl food crops.

Soy-beans are subject to considerable local preference, but in some sections, are well used by both ducks and geese. The large-seeded varieties such as Mammoth Yellow or Woods Yellow, and oil varieties such as the Ogden are preferred. During wet weather, soy-beans are subject to rapid deterioration.

The various species and varieties of millets are generally well taken by waterfowl, and combine the advantages of a short growing season and the ability to produce fair yields from broadcast plantings. Buckwheat has the advantage of an extremely short growing season, allowing planting at a later date than other crops palatable to waterfowl. However, both the millets and buck-

wheat may require flooding for maximum waterfowl usage. They sometimes work well on low-lying fields or in basins which dry out too late in summer for normal cropping and are covered with water during winter floods. On sandy, coastal-plains soils, cowpeas have been used with some success. Varieties showing the least tendencies of seed to rot and mold during winter should be used.

Browse Plantings for Goose Usage:

Fall plantings of crops which remain green through the winter can furnish grazing that is well used by geese. Such usage is heaviest during warm periods through the fall and early winter, and becomes general in late winter and early spring when the birds abandon the higher-nutrition crops in favor of grazing. Such grazing if extremely heavy may reduce the seed or hay production of these crops. The following have been found best adapted for this use:

Alfalfa is usually a highly-preferred browse. The fact that it is a perennial, combined with its soil-building properties and heavy production, makes it especially desirable.

Crimson clover is a highly-preferred browse. The reseeding variety can be used to reduce the need for yearly planting.

Ladino clover has not been used extensively as a browse plant, but future planting may prove its value for this purpose.

Austrian peas are subject to heavy goose usage and are well suited to conditions in the central parts of the Southeastern States.

Wheat, oats, and rye grass furnish excellent goose grazing. Rye and barley are less desirable as a goose browse, and are only slightly used if the more desirable small grain and legume browses are available. Vetch is sometimes used, but produces low quality browse.

Combination Plantings:

Combination plantings designed to furnish both mature grain and green browse at the same time represent the ideal and are possible. Corn, milo, peanuts, or other summer crops can be followed with cover-crop plantings of crimson clover, Austrian peas, or vetch and grain mixture. Properly done, these plantings will produce excellent browse in conjunction with the hard seed furnished by the summer crop. In addition, soil-building and protection benefits are received.

Potential Crops:

There are several crops which show considerable promise for use as waterfowl food, but these have not been used extensively in the Southeast. Some of these crops are: chufa, upland rice, various varieties of beans and peas, clovers and other legumes, kale, rape, and a great many others. Some of these will not fit into the local farm economic picture under a share-crop system, but might be adaptable to a program of farming by the managing agency.

SPECIAL PLANTING AND HARVESTING TECHNIQUES

While upland farming for waterfowl use can normally follow accepted farming practices, as recommended by local experiment stations, certain special techniques of planting and harvesting are desirable for maximum usage. The following recommendations apply to sanctuary areas. Where public-hunting

grounds and club-owned or private preserves are concerned, harvesting techniques must be modified to conform with State and Federal anti-baiting laws.

General:

Where the share-rental system is used and rental tracts are well located for waterfowl use, the rental portion is best left in the field as a series of unharvested rows alternating with strips of harvested ones. If the entire tract is not well located, the rental portion should be taken as a solid block or strip in the best located portion of the area.

Waterfowl come readily to fields harvested by foraging livestock. When this method is used, careful supervision is required to insure that the birds get a proper share.

No crop should be dragged down for waterfowl use until fully mature. To prevent sprouting during warm fall weather, this dragging down of crops should not commence until migrant birds begin to arrive. Where possible, it is often desirable to drag down crops through the late fall and early winter, rather than during a single short period, in order to prevent too rapid consumption.

Following are special techniques as related to specific crops:

Corn: Where corn is left for waterfowl food, it should be knocked down by a stalk cutter, a disc set without angle, or a pole drag. If a disc is used, care must be taken not to cover ears. Where the share system is used, stalks should be cut down on both the harvested and the unharvested portions. This reduces predator cover and allows birds to glean ears inadvertently missed during harvest.

Peanuts: Where soils are very loose and vegetative growth is not excessive, waterfowl will take peanuts without special treatment. In heavier soils, the nuts must be exposed by plowing up the individual rows with a turning plow or similar implement. Where peanut tops and other vegetation are heavy, it may be necessary to have this mowed for hay after the nuts mature, to obtain good waterfowl usage.

Grain sorghums: In some localities, waterfowl have made good use of standing grain sorghum. This is especially true where sleet or snow can be depended upon to weight down stalks. In other localities, good usage is obtained only when stalks are mowed or cut with a stalk cutter. The use of a pole drag is usually not satisfactory since stalks spring up behind it. Discs should not be used since seed are too easily covered. Due to the tendency of these seeds to deteriorate rapidly, special care is required to insure that stalks are not cut too far in advance of expected usage and that seed are not made available in too great quantity for quick consumption.

Soy-beans and Cowpeas: Good soybean and cowpea usage may be obtained without special treatment. When necessary to level the crop to obtain usage, a stalk cutter or mower should be employed in preference to a disc or drag. Harvesting the crop with a combine, letting at least 50 percent of the beans spill through, leaves a field in excellent condition for waterfowl use. Sprouted beans are not wasted since these are readily consumed, especially by geese.

Alfalfa: Where alfalfa is used for winter goose browse, care must be taken to time the last mowing in such manner

that all rough is removed. Winter fields should present only the short new growth.

Other Winter Legumes and Small Grains: Crimson clover, Austrian peas, wheat, oats, rye, barley, and rye grass, when planted exclusively for goose browse, should have their rates of seeding increased by approximately 50 percent above the rates normally recommended for purely agricultural plantings. Care must be taken not to plant such crops so early that a rank, tough growth results before browsing begins. However, plantings must be made sufficiently early so that the young plants will be well rooted before the geese arrive. Heavy goose browse on young, poorly-rooted stands can result in a high proportion of the crop being pulled up.

Efforts in the Southeast to leave mature wheat, oats, rye, or barley in the field for waterfowl use have not been successful. The grain usually matures in June, and hot weather and summer rains rot it long before wintering birds arrive. Vetch should never be planted solely for waterfowl use, but it is a valuable cover crop and is sometimes used by geese. Blue lupine, a valuable winter cover crop for the sandy soils of the Coastal Plains, is not known to have any browse value.

SUMMARY

The southeastern states are the wintering grounds for a high proportion of the continent's waterfowl, but a rapidly expanding population, agriculture, and industry are limiting the natural food supply. Upland farming furnishes one successful means of supplementing this natural supply. However, this applies only to the geese and certain field-feeding species of ducks.

Maximum food production is possible when the operating agency farms the available land with its own personnel. Another method, share rentals, makes available a smaller amount of food for waterfowl but permits farming with little cost to the agency concerned.

Waterfowl management through upland farming includes the planting of corn, grain sorghum, rice, peanuts, and soy-beans to furnish high nutrition food during winter. It includes the planting of alfalfa, crimson clover, Austrian peas, wheat, oats, rye, barley, or rye grass to provide grazing for geese. With slight variations, normal agricultural practices should be followed. Variations include the proper timing of winter legume and grain plantings to prevent goose damage, and furnish succulent browse and late mowing of alfalfa fields to eliminate rough. Where row crops are concerned, special techniques of planting and cultivation are not necessary, although the cleanest possible cultivation is desirable. Special harvesting methods are necessary and, in general, standing crops must be dragged down and peanuts plowed up at about the time migration begins.

Farming has been used as a waterfowl-management tool in the southeast for over a decade. Properly handled, especially where share rentals are used, it is neither costly nor difficult. It has resulted in pronounced increases in wintering waterfowl in many widely scattered portions of the southeast.

Accepted for publication October 18, 1951.

THE SOURCE OF MIGRANT MOURNING DOVES IN SOUTHERN FLORIDA

John W. Aldrich

U. S. Fish and Wildlife Service

The Problem

There has been a separate early open season on the Mourning Dove for the southern three counties of Florida (Monroe, Dade and Broward) for a number of years. During recent years the southern Florida season has been the month of October, while the season in the rest of the state has started about two months later. The original basis for dividing Florida with respect to the open season in this way was the fact that doves usually appeared in numbers in the extreme southern counties early in the fall and were abundant for only a short time. A belief has become prevalent that this early flight of doves in southern Florida originates in the West Indies and thus the doves that are shot in Monroe, Dade, and Broward Counties are from an entirely different breeding population from that hunted in counties to the north. This theory has continued to give support for a separate open season.

Evidence for West Indian Origin

The source of the theory that the southern Florida dove population is made up largely of birds from a West Indian breeding population is obscure. However, it appears to have been based on observations of numbers of Mourning Doves migrating in fall up the Keys toward the mainland and northward through the southern counties. These observations have been described in detail in reports by Harold S. Peters (1941 and 1948) and by Frederick C. Lincoln (1945). There seems to be abundant evidence that such a northward flight does occur in the fall in southern Florida, both from observations in the field and from the banding records. Of the approximately 6,500 birds banded at Key West, mostly during the nineteen thirties, by the late Wm. W. Demeritt, there were numerous direct recoveries during the same fall migration from points to the northward in Florida and even as far as the southern part of Georgia (Fig. 1).

The fact that this northward migration was observed early in the fall season in southern Florida without any preceding southward movement having been detected, has been considered as evidence that the doves observed must have come from some breeding area to the south of Florida; and the island of Cuba is the nearest area in that direction where the Mourning Dove breeds in numbers. It seems to be the concensus of opinion that neither the Florida Keys nor the mainland of extreme southern Florida affords a breeding population sufficiently large to have been the origin of the large numbers of birds sometimes reported (Peters, 1941; and Lincoln, 1945). Peters has suggested that the hurricane which swept up into southern Florida prior to his 1948 investigations might have brought in birds from Cuba

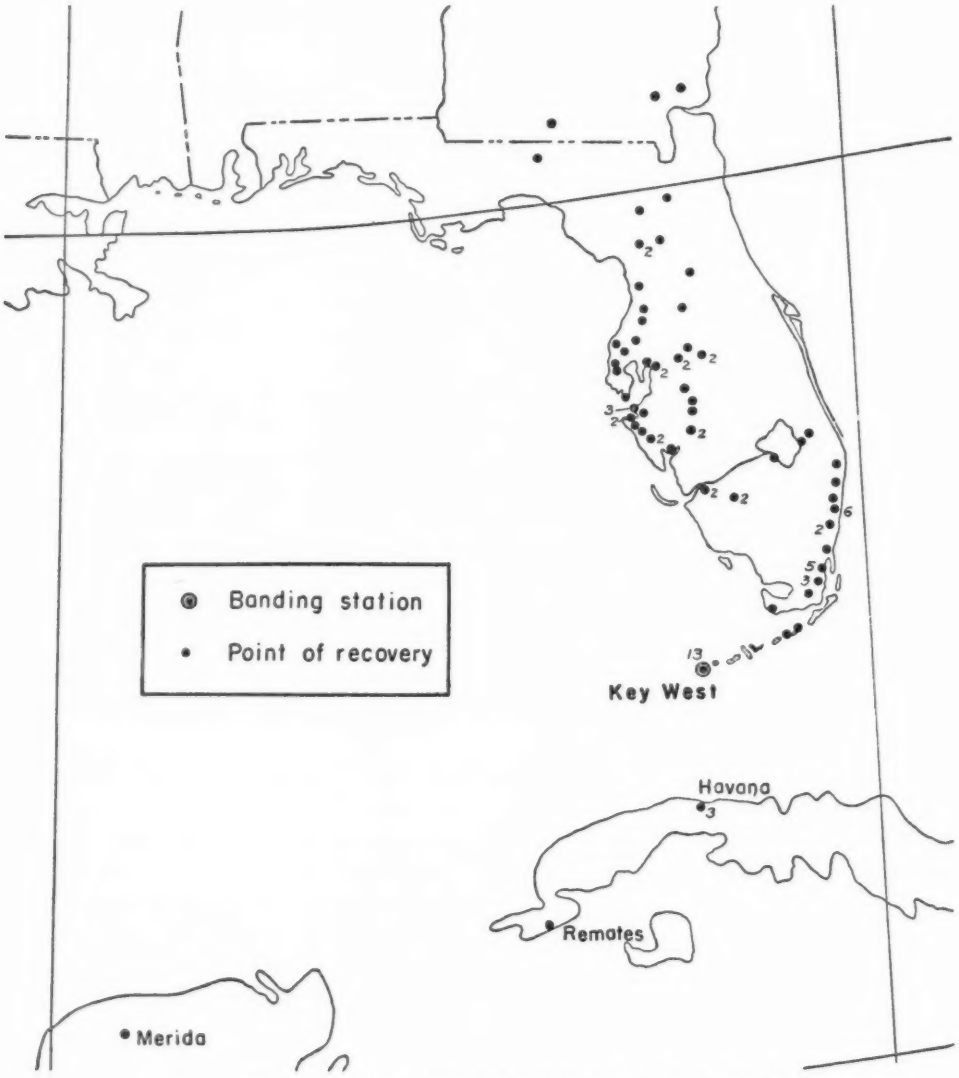


FIG. 1. Direct recoveries of birds banded at Key West, Florida.

and accounted for the large number of birds present that year. However, reports do not indicate any noticeable change in the dove population after the severe hurricane during the middle of October of 1950, and sportsmen report that there are fewer doves after hurricanes than before (*fide* F. C. Lincoln).

STUDY OF SPECIMENS

Previous to the present study the writer had identified as the eastern North American race, 6 specimens of Mourning Doves taken by Frederick C. Lincoln and one by Harold Peters, as well as 2 old specimens in the National Museum collection, all taken in southern

Florida during migration. However, up until the present investigation there has been no attempt to identify a large sample of the Mourning Doves taken during the southern Florida hunting season, to determine whether they belonged to the race which breeds in the West Indies or that of eastern North America, or even that of western North America. Because of the importance which had become attached to the theory of West Indian origin of southern Florida doves in connection with formulation of Federal hunting regulations, the writer was delegated by the Fish and Wildlife Service to investigate this matter, during the hunting season of 1950. In preparation for these investigations a study was made of 311 Mourning Dove specimens in the United States National Museum collection, and the limits of geographic variation of the two North American races and the one West Indian race were determined.

The West Indian race of Mourning Dove, *Zenaidura macroura macroura*, is distinguishable from the eastern North American race, *Zenaidura macroura carolinensis*, by having in all plumages, a deeper, more reddish buffy wash to the under parts and, in adults, by smaller size. Thirty-nine adult male specimens of West Indian Mourning Doves had wings ranging in length from 134 to 146, averaging 138.3 mm., whereas 54 male Eastern Mourning Doves had wings ranging from 140 to 157, averaging 146.7 mm.; 18 adult female West Indian birds had wings ranging from 128 to 138 and averaging 131.9 mm., whereas 24 female Eastern Mourning Doves had wings ranging from 135 to 144 and averaging 140.1 mm. Although there was considerable overlap in the measurements of these two races, the color differences were much more absolute, with only a slight overlap. By combining color and size characters it was found that a very high percentage of specimens of the West Indian race could be distinguished from specimens of the Eastern Mourning Dove. The specimens of the Western Mourning Dove were found to be different in all plumages from the other two races in the paleness of both upper and lower parts. They lacked the bright cinnamon buff of the under parts characteristic of the West Indian birds and in this respect they were more like the eastern North American race. There was no significant size difference between the eastern and western races. After working out the ranges of variation in coloration of these three subspecies, typical examples of each, including different sex and age plumages, were selected to use as standards for identifying specimens in the field.

With this preparation the writer spent the first 15 days of the hunting season (October 1 to October 15, 1950) in company with game officers in southern Florida, examining Mourning Doves in hunters' bags. During that period a total of 299 specimens were identified. The specimens were first sorted according to age in three categories. If the white feather edgings, characteristic of juvenal plumage, were present on the body plumage, the bird was grouped as a juvenile. If all of the white edgings, except the greater primary coverts, had been lost it was listed as immature. If all white-edged feathers had been molted, the specimen was classified as adult. Undoubtedly some of the earliest hatched birds of the year had already

molted the last juvenal primary covert and thus were mistaken for adults. Of the total birds examined, 23.4 percent were classified as adults, 52.8 percent immatures, and 23.7 percent juveniles. Thus 76.5 percent were young of the year.

The next step was to sort the immature and mature specimens by sex on the basis of coloration of breast and head plumage. In these age groups it is possible, with experience, to distinguish fairly easily between the brighter, pinkish breast of the males as contrasted with the duller brownish breast of the females. It was not found practicable to attempt to determine the sex of the juveniles which have not yet molted their body plumage. The sorted doves were compared with specimen samples of the appropriate age and sex of the three races which I carried about with me in a flat box. The wings of all adult specimens were measured and recorded. Final identifications were made on the basis of color of young birds and combined color and measurements of adults. On this basis, of the 299 specimens examined, 4 (1.3%) were identified as the West Indian race, *macroura;* 4 (1.3%) as the western race, *marginella;* and 291 (97.3%) as the eastern race, *carolinensis.* The specimens of the West Indian and Western Mourning Dove were fairly well scattered as to locality and date. The West Indian Mourning Doves were an adult male, Perrine, Oct. 1; immature male, Golden Glades, Oct. 4; adult male, Virginia Gardens, Oct. 7; and immature male, Kendall, Oct. 8, all in Dade County, Florida. The specimens of Western Mourning Dove were an immature male, Perrine, Oct. 1; a juvenile, Perrine, Oct. 2; an immature female, Virginia Gardens, Oct. 7, in Dade County; and a juvenile, West Deerfield, Broward County, Florida, Oct. 11. No effort was made to obtain any of these specimens for preservation because it was important not to jeopardize the continued cooperation of the hunters in making these birds available for study.

The percentage of young of the year ranged from 75% on October 1 to 80% on October 7, and averaged 76.5% for the first 15 days of the season. This is considerably lower than the 95.4% found by Peters from October 16 to November 9 in the large flight of 1948, or even the 90% based on 1,481 doves examined during the entire season of 1950 (Peters, 1951). This may indicate that doves which migrate to southern Florida are practically all young birds, and that the early season birds are made up to a large extent of locally reared birds, including a higher proportion of adults. However, it should be noted that two of the four West Indian Mourning Doves identified were adults. Although all four of the Western Mourning Doves examined were young of the year, the sample was not large enough to prove that only young birds of this race ever reach southern Florida.

On the basis of my 1950 observations and specimen identifications it is concluded that the Mourning Doves which were shot in southern Florida during the first two weeks of the 1950 season did not come primarily from breeding populations in the West Indies to the south, but rather to a very large extent from breeding grounds in the eastern United States. Information is insufficient at present to determine the relative abundance of locally reared doves on the

south Florida shooting grounds. However this question is being investigated by Florida State Biologist Frank Winston.

THE 1950 MIGRATION

Table 1 gives the dates on which Mourning Doves were identified and the numbers of each age group identified on these dates. From this table it is apparent that by far the largest number of doves examined was on the first day of the hunting season (Sunday, Oct. 1). From all reports this reflects the number of doves present on the shooting grounds as compared with the two subsequent Sundays (Oct. 8 and 15). There was a rapid decline in the number of doves found in hunters' bags after the first day of the season, with an increase indicated on the 7th and 8th of October. This increase was partly due to the fact that it was a week-end which would bring more hunters into the field, and also to the opening of a shooting ground which had not been shot in previously and in which the birds had remained in fair numbers. The fact that the two preceding days were very rainy, keeping the hunters at home also may have had its effect. Field observations failed to disclose indication of a general increase in doves in the region on the week-end of the 8th. The next increase in bagged doves is shown on October 15, which took place on areas that had very poor shooting for over a week previous to that time. All observations seemed to indicate that it probably represented an actual influx of doves into the region. This influx coincided with a fairly strong cold front which arrived in southern Florida the morning of October 14, on which date the writer was in the Florida Keys. The one party of hunters encountered between Key Largo and Long Key reported that doves were much more numerous that day than at any time since the opening of the season. That evening in Miami, I received reports from hunters that shooting grounds at Opa Locka had produced more doves than at any time since the first few days of the season. I, therefore, concluded that the influx of doves on the cold front of October 14 had been fairly general. Peters (1951) noted an increase of doves in the Miami area on October 27, 1950, following a cold front. This coincided with the first big flight of the year on the Keys noted by Robert Allen between October 25 and November 1, and reported by Brookfield (1951).

From various sources I obtained the information that the hunting season in 1950 had produced an average number of Mourning Doves; that the shooting had not been as good as it was in 1948;

TABLE 1.—MOURNING DOVES IDENTIFIED IN SOUTHERN FLORIDA, 1950

Date Identified	Adult	Immature	Juvenile	Total
October 1	26	54	26	106
" 2	5	0	4	9
" 3	3	4	5	12
" 4	8	9	6	23
" 7*	16	52	15	83
" 8	2	4	4	10
" 9	0	0	0	0
" 10	0	0	0	0
" 11	1	2	3	6
" 12	0	0	0	0
" 13	0	1	0	1
" 14	0	5	1	6
" 15	9	27	7	43
Totals	70	158	71	299
Percent of totals	23.4%	52.8%	23.7%	
			76.6%	

* No observations were made on Oct. 5 and 6 because of hard rains during shooting periods.

but that it was somewhat better than in 1949. It should be noted that the areas favorable for dove concentrations were quite limited in number and extent and were all hunted regularly. Therefore the observations of hunting success were probably an accurate index to dove abundance during the first two weeks of October of an average year. Thus the proportions of the three races of Mourning Doves identified in hunters' bags were probably normal for that time of year also.

EVIDENCE FROM BANDING RECORDS

The specimen evidence cited above shows that the doves present during the shooting season in southern Florida come to a large extent from breeding populations of the eastern United States but the question remains how extensive this area is. On this question we may obtain considerable information from the banding records of the U. S. Fish and Wildlife Service. Fig. 2 shows the locality at which birds banded at Key West by the late Wm. W. Demeritt have been recovered outside of Florida during the nesting and fall migration seasons. It also shows the reverse picture of doves banded to the north and recovered in southern Florida. It can readily be seen that the area from which these doves came, extends from the Atlantic seaboard to east Texas, and from Illinois to Georgia. The especially large concentration of these recoveries in the state of Illinois probably reflects the fact that this is the only northern state which had a hunting season during the nineteen thirties when banding was in progress at Key West. However, it is significant that there were more recoveries from the northern state of Illinois than for any of the southern states except Florida. This is despite the fact that birds from northern breeding grounds must pass through the southern states to reach Florida, and all of these have open seasons on doves. The reverse picture of recoveries in southern Florida of doves banded in other states, although based on few records, also suggests the importance of the more northern midwestern states as producers of southern Florida dove flocks.

If we examine all of the recoveries of doves in Florida which were banded in various states to the north (only those from southern Florida are shown on Fig. 2) we find that their points of banding cover an extensive area of the eastern United States. It should be noted that a relatively small percentage of doves banded in the north and recovered in Florida were recovered in the southern part of the state. This probably indicates a relatively high shooting pressure in the northern counties as compared with the southern. The fact that many of the fall migrant doves banded at Key West were subsequently recovered farther north during the same fall migration indicates that many of the birds shot in the northern part of the state could have made the trip to the southern tip first before being finally brought to bag in the northern section during its later hunting season. In contrast to the recoveries of migrant birds, doves banded in southern Florida during the breeding season have been recovered exclusively in the same general region. This indicates that the southern Florida breeding population is largely sedentary. It is significant that all but one of the recoveries of doves south of Florida are direct fall migration

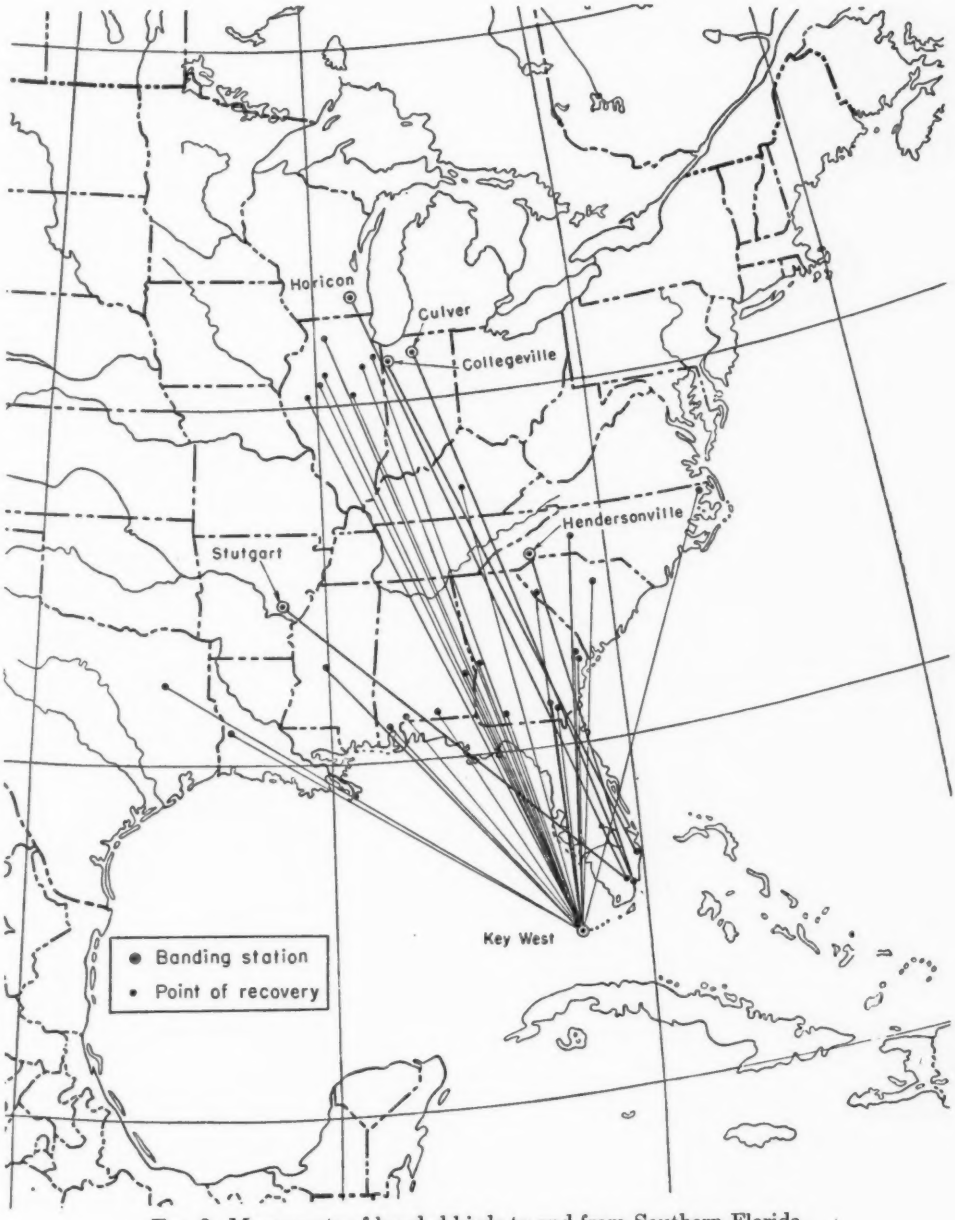


FIG. 2. Movements of banded birds to and from Southern Florida.

recoveries, indicating a northern rather than a southern origin. The one exception, April 1, 1939 at Las Martinas, Pinar del Rio Province, Cuba, is the only one that could conceivably have been of West Indies origin. Dr. Abelardo Moreno informs me that the locality is one of the best breeding areas in Cuba

for Mourning Doves and April 1 is within the breeding season for doves there.

FLUCTUATION IN MIGRATION INTENSITY

There seems to be general agreement that the number of doves present in southern Florida varies greatly from year to year. Also there is considerable variation in the dates on which the big flights arrive. It is well known that southward migration of birds in general tends to coincide with the movements of masses of cold air, the advance edges of which are called "cold fronts." It was in the latter part of October 1948, when Harold Peters reported that a very large number of doves were shot in southern Florida. There is no exact record of the intensity of migration during the season of 1949 but hunters seem to agree that it was a relatively poor season. Correlated with these observations it may be noted in the weather records that there were more and stronger cold fronts reaching southern Florida during October 1948 than in the same period of 1949. In fact in 1949 no cold front of the magnitude of those of 1948 reached southern Florida until November 2. Since this was after the end of the hunting season an influx of doves at that time might not have been noticed. In 1950 doves were present in numbers before the beginning of my observations on October 1, the opening day of the shooting season. Their numbers were decimated very markedly during the first two weeks of the season and then increased noticeably after the arrival of a cold front on the 14th. Peters (1951) and Brookfield (1951) reported another increase during the last week of October, following a cold front.

The banding schedules of the late William W. Demeritt of Key West, recording the banding of approximately 6,500 doves, contain probably the most extensive and accurate information on Mourning Dove migration over about a 10-year period for any southern Florida locality. Demeritt's reports contain such notations as this: "On Nov. 9, 1930 northwester blowing, hundreds of doves at station." "Dec. 14, 1932, saw very few. On Dec. 20 about 150 with a strong cold northerly wind blowing."

HOW MIGRANT DOVES REACH SOUTH FLORIDA

The most baffling feature of the migration of Mourning Doves into southern Florida has been the arrival of large numbers of these birds in the southern counties without being noted on their way south. This has been one of the chief reasons that credence has been given to the theory of West Indies origin. One suggestion has been that these birds move down the west coast. However, up to the present time information on flights of doves in that area is lacking. Questioning of sportsmen from the southwestern coast area has failed to elicit information of noticeable flights of birds there. William D. Wood, manager of the Sanibel National Wildlife Refuge on Sanibel Island, southwest of Fort Meyer, reported 56 Mourning Doves there from September to December 1950, but there is no way of knowing whether these birds were headed north or south. Florida state biologist Frank Winston is now investigating this problem through banding and coloring doves trapped in the northwestern part of the state.

That few Mourning Doves reared in North America get south of the Florida Keys is attested by the fact that so few banded birds have been reported from the West Indies, where it has been noted by Dr. Abelardo Moreno of the University of Havana that Mourning Doves are shot in large numbers. Only 6 doves banded in the United States have been recovered in the West Indies, while one was recovered to the south of Cuba in Yucatan. This is even more remarkable when we realize that more doves have been banded at Key West, the nearest point in the United States to Cuba, than at any other station in North America, and no less than 168 of these have been recovered.

CONCLUSIONS

The general conclusions which can be drawn from the results of both banding and specimen evidence are that Mourning Doves which are shot in southern Florida are largely migrants of the breeding population from a very extensive area east of the Mississippi River; that they include an especially high percentage of young birds; that a large percentage of these birds appear to come from breeding grounds in the extreme northern part of the species range; that they reach the southern tip of Florida in varying numbers from late September to early November, accompanying movements of large masses of cold air to the southern tip of Florida during the migration season. The number and intensity of cold fronts during that period may control, to some extent, the number of migrant doves that will reach southern Florida. The reproductive success of doves in the northern states during that year presumably would also have a considerable effect on the numbers of birds reaching southern Florida, since such a large percentage of this population is composed of young of the year. During periods when no large migrations arrive from the north the doves shot in southern Florida presumably consist to a greater extent of the relatively sedentary local population. At such times it might be expected that a higher percentage of adult birds would be present.

The period beginning in late September or early October, when doves normally begin to appear in numbers in southern Florida, is preceded by a concentration of doves in the southeastern states to the north of Florida in late August and early September. These concentrations appear to decrease just prior to the time that southern Florida populations normally build up (Peters, 1943). During the course of flights of doves into Florida, it appears that upon reaching the southern tip of the peninsula the majority of these birds stop their southward progress. Thus most of the birds land either in the Keys or the southern tip of the mainland, move northward along the east coast to the latitude of Lake Okeechobee; thence they appear to cross the peninsula and move northward along the west side, gradually spreading out into the northern part of the state and south Georgia (Fig. 1). A few occasionally proceed across the straits to the West Indies. This migration appears usually to diminish noticeably during the latter part of November.

ACKNOWLEDGMENTS

For valuable assistance while in the field in Florida I am greatly indebted to

U. S. Game Management Agent Jacob Wolfley, to Florida Game and Fresh Water Fish Commission Officers I. P. Hodges, W. P. Cooper, Jack Spaulding, and particularly to I. H. Schwartz, who took me with them on their patrols of the dove shooting fields; also to an interested group of sportsmen, the dove hunters who cooperated in a most cordial and helpful manner in allowing me to handle and carefully study the doves which they had shot. I am especially indebted to my colleague, Harold S. Peters, who has had considerably more field experience in southern Florida than I have had, for reading the manuscript and offering a number of helpful suggestions.

REFERENCES CITED

BROOKFIELD, CHARLES M. 1951. Region Reports, Fall Migration, Florida Region. Audubon Field Notes, 5: 10–12.

DEMERITT, WILLIAM W. 1931–1940. Bird-banding Schedules. (in files of Fish and Wildlife Service).

LINCOLN, FREDERICK C. 1945. Report on Trip to South Florida to Investigate the Status of Mourning Doves, September 26-October 6, 1945 (unpublished report in files of the Fish and Wildlife Service).

PETERS, HAROLD S. 1941. Southern Florida Mourning Dove Investigations, December 2–16, 1941 (unpublished report in files of Fish and Wildlife Service).

———. 1943. Dove Investigations in Mississippi and adjoining States, September 27-October 24, 1943 (unpublished report in files of Fish and Wildlife Service).

———. 1948. Mourning Dove Investigations in Southern Florida, October 21 to November 10, 1948 (unpublished report in files of Fish and Wildlife Service).

———. 1951. Mourning Dove Investigations in Southern Florida, October 1950 (unpublished report in files of Fish and Wildlife Service).

Accepted for publication Dec. 3, 1951.

FOOD HABITS OF THE GOLDEN EAGLE

Wesley Woodgerd

Montana Cooperative Wildlife Research Unit, Montana State University
Missoula, Montana

In March of 1948, 286 golden eagles (*Aquila chrysaetos*), were killed in Carter County, Montana. The Montana Fish and Game Department paid a bounty of five dollars each. The bounty on golden eagles was initiated by demands from sportsmen and ranchers and action was taken when personnel of the Fish and Game Department observed eagles preying on antelope. The bounty served the dual purpose of reducing the number of eagles in the area, and as a means of collecting stomach samples. Fifty-one stomachs were saved from the bountied birds, and later sent to Montana State University for analysis of the contents.

The stomachs were analyzed as to frequency of occurrence of the various food species present. Whenever possible, bone and dentition characteristics were used in identifying the mammals. If bones or teeth were not included in the stomach contents a hair key (Mathiak, 1938) was relied upon for identification. The feathers found in the stomachs were identified by comparison with museum specimens whenever possible.

A total of eight stomachs (15.7 per cent) contained antelope remains. The infrequency of antelope in the stomachs is at variance with statements made by the two aerial hunters who accounted for the majority of the eagles brought in for bounty. One of them stated (Brown and Couey, 1950) "that 4/5 of the eagles he shot down showed signs of having fed on antelope; this was either in the form of hair in their claws or regurgitating antelope hair when hitting the ground. The other hunter stated that more than 1/2 of those he killed showed similar signs of having fed on antelope."

Reports indicate (Brown and Couey, 1950) that eagles attack and kill both mature and juvenile antelope by landing on the animal's back and riding intermittently until the antelope falls from exhaustion and loss of blood. The lifting power of an eagle remains a controversial subject, but it would seem to be possible for one to carry a young antelope fawn for a short distance.

Casebeer, Rognrud and Brandborg (1950) recorded an observation of a bald eagle picking a young mountain goat weighing six to seven pounds from the face of a cliff and soaring about one-third of a mile before stopping. Gordon P. Seton (1937) wrote of an eagle lifting a 9¾ pound lamb from a hillside and carrying it "some little distance" before stopping to rest. He (Seton) also mentioned a gamekeeper on the Isle of Skye who found an eagle with an eight pound steel trap on one foot. The trap was of a kind not used locally, and was thought to have been carried at least twelve miles across the sea. Lewis and Marion Walker (1939), after conducting experiments on the lifting power of a pet golden eagle, state: "We doubt very much if a wild eagle in perfect condition can lift eight

pounds off the ground. A female (the larger sex) might be able to carry such a load if flying speed could be obtained by dropping off a cliff." E. S. Cameron (1905) wrote an account of lambs being carried off while the eagles had young in the nest, and also (1908) of three golden eagles killing an adult buck antelope during severe winter weather near Knowlton, Montana. Dixon (1934) stated that he personally knew of three mule deer fawns having been killed by golden eagles. He also has examined 60 nests and none contained any deer remains. Hanna Wilson (1930) wrote "it is my opinion that the golden eagle is a decidedly beneficial bird. Remains of food in their nests would indicate that the ground squirrel is the chief food and rabbits second." James B. Dixon (1937) wrote that "squirrels, both tree and ground, are the first and foremost item of food. Next in importance are the three kinds of rabbits found in this region. Ranking third are the various water birds such as the coot and the larger ducks. The eagles are not particular, as we have found skunks, gray foxes, housecats, young pigs, young deer, and young goats in or at the bases of nests."

TABLE 1.

STOMACHS CONTAINING ONE SPECIES ONLY

* Jack Rabbit, *Lepus townsendii*	22	
Antelope, *Antilocapra americana*	3	
Domestic sheep	1	
Sharptail Grouse, *Pedioecetes phasianellus*	1	
Prairie Dog, *Cynomys ludovicianus*	2	
Cottontail Rabbit, *Sylvilagus spp.*	2	
Meadow Mouse, *Microtus spp.*	1	
Deer Mouse, *Peromyscus spp.*	1	
Ground Squirrel, *Citellus spp.*	1	
Chinese Pheasant, *Phasianus colchicus*	1	35

STOMACHS CONTAINING MORE THAN ONE SPECIES

Jack Rabbit and Meadow Mouse	3	
Jack Rabbit and Deer Mouse	2	
Jack Rabbit and Domestic Sheep	2	
Meadow Mouse and Small Bird	1	
Meadow Mouse and Domestic Sheep	1	
Cottontail Rabbit and Pocket Gopher	1	
Antelope and Jack Rabbit	1	
Antelope and Unidentified Mouse	1	
Antelope and Cottontail Rabbit	1	
Antelope and Unidentified Feather	1	
Antelope and Deer Mouse	1	15
Unidentified meat	1	1
		51

* Cottontail and Jack Rabbits may not be accurately separated; when only hairs from these animals were present identification was uncertain.

Eagles, like most predators, apparently utilize the source of food that is most easily available to them, and the degree to which they prey on game animals is influenced largely by the availability of other food. The amount of carrion in the diet is a matter for speculation. Brown and Couey state that as the winter of 1947–48 was not a severe one, carrion feeding should have been at a minimum. It is quite probable that the domestic sheep represented in the diet resulted from feeding on carrion, and undoubtedly some of the antelope also. Of six stomachs analyzed by Fisher in 1893, two were found to contain carrion, one was empty, one contained an Abert's squirrel, one a rabbit, and one contained unidentified feathers. From this limited sample it would appear that carrion might form an important part of a golden eagle's diet at least at certain times of the year.

SUMMARY

Fifty-one golden eagle stomachs were analyzed as to frequency of occurrence of the various species of animals taken for food. The main item in the diet was

found to be jack rabbit, with twenty-two stomachs containing only jack rabbit and four containing jack rabbit along with other species. The occurrence of antelope was next, with three stomachs containing only antelope and five having antelope in conjunction with other species.

Instances of golden eagle predation are cited, and the lifting power of eagles is discussed. A ten-pound animal would apparently be too heavy to be carried, but this does not exclude the possibility of larger animals being killed by eagles. The eagle is an "opportunist" in his feeding habits and the extent of damage or the amount of benefit derived from eagle predation are correlated directly with the composition of the populations on its range.

LITERATURE CITED

BROWN, DON L., and FAYE M. COUEY. 1950. Eagle-Game Relationship in Montana. Third Annual Northwest Wildlife Conference.

CAMERON, E. S. 1905. Nesting of the Golden Eagle in Montana. Auk, **22**(2): 158–167.

CAMERON, E. S. 1908. Observations on the Golden Eagle in Montana. Auk, **25**(3): 251–268.

CASEBEER, ROBERT L., MERLE J. ROGNRUD, and STEWART BRANDBORG. 1950. The Rocky Mountain Goat in Montana. Montana Fish and Game Commission, Wildlife Restoration Division, Bul. No. 5.

DIXON, JAMES B. 1937. The Golden Eagle in San Diego County, California. Condor, **39**(2): 49–56.

DIXON, JOSEPH S. 1934. A Study of the Life History and Food Habits of Mule Deer in California. California Fish and Game, **20**(3): 181–282 and **20**(4): 315–354.

MATHIAK, HAROLD A. 1938. A Key to Hairs of the Mammals of Southern Michigan. Jour. Wildl. Mgt., **2**(4): 251–268.

SETON, GORDON P. 1937. The King of Birds. Natural History, **39**(5): 353–356.

WALKER, LEWIS, and MARION WALKER. 1939. From Egg to Eaglehood. Natural History, **43**(5): 284–289, 302.

WILSON, HANNA C. 1930. Notes on the Golden Eagle in Southern California. Condor, **32**(2): 121–123.

Accepted for publication Dec. 3, 1951.

THE CALIFORNIA QUAIL IN NEW ZEALAND

Gordon R. Williams

New Zealand Wildlife Service

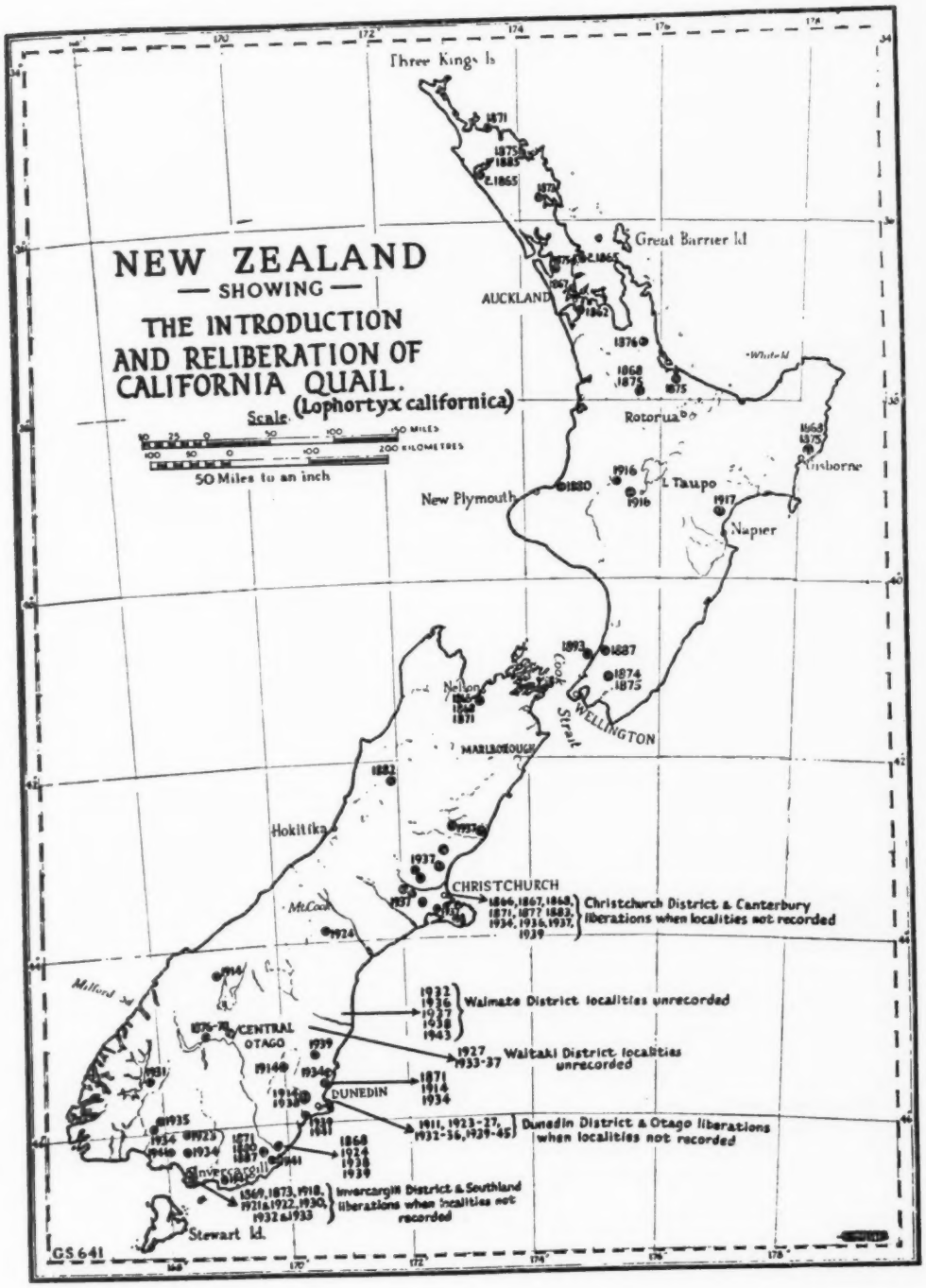
Historical

Of the many game birds introduced into New Zealand since settlement, the California quail has so far proved to be the most successful—being now widely distributed over both main islands. After the initial importations between the years 1860 and 1870 the spread of the species has been entirely brought about by trapping and reliberation of New Zealand-bred stock and natural dispersal from the many liberation points. Although Thomson (1922) gives an account of the liberations and distribution of the California quail up to about the year 1920, this is by no means complete even to his time. In making the present compilation, recourse has been had to five main sources of information: firstly, Thomson in the work already cited; secondly, Hutton (1869); thirdly, Drummond (1906); fourthly, the Annual Reports of the various acclimatization societies; and fifthly, the records of the Department of Internal Affairs.

The first liberation of California quail in New Zealand is stated by Thomson to have been in the province of Nelson in 1865 and this date is the one usually accepted. However, Hutton should be more reliable—being almost contemporaneous with the event—when he records that two pairs were liberated by a Mr. W. Hay at Papakura, near Auckland, in 1862. He goes on to say that "these are now in thousands and have spread for many miles."

Credit for the establishment of this now-important species is due to the various acclimatization societies; but when an attempt is made to trace fully the birds' spread throughout the Dominion, one is handicapped by the lack of adequate records in the annual reports of these societies. Therefore it is not claimed that the list of liberations incorporated in the map is complete—the best use possible has been made of the material existing. Had full information been available each liberation with its date would have been plotted individually. The vagueness of most of the records has made this impossible; occasionally place names are given but most references simply state that so many quail for a given year were set free "in suitable areas" in a given acclimatization district. A detailed list incorporating the place, date and number of birds in each liberation traced would be out of place in the present paper as it presupposes much familiarity with local geography and the availability of large-scale maps. The intention is to publish such a list in a more fitting place at an early date.

To account for the wide colonization of the species not only within a few decades of their introduction but even today, it is obvious that there have been numerous unrecorded liberations over most of the country. For example, it is unlikely that quail have spread of their own accord from the nearest recorded liberation points at Tauranga,


NEW ZEALAND
— SHOWING —
THE INTRODUCTION AND RELIBERATION OF CALIFORNIA QUAIL.
(Lophortyx californica)
Scale
50 Miles to an inch
Three Kings Is
Great Barrier Id
AUCKLAND
Rotorua
Gisborne
L Taupo
New Plymouth
Napier
WELLINGTON
MARLBOROUGH
Cook Strait
Hokitika
CHRISTCHURCH
Christchurch District & Canterbury liberations when localities not recorded
Walmate District localities unrecorded
CENTRAL OTAGO
Waitaki District localities unrecorded
DUNEDIN
Dunedin District & Otago liberations when localities not recorded
Invercargill
Invercargill District & Southland liberations when localities not recorded
Stewart Id.
GS 641

Waikato and Gisborne into the area about Lakes Taupo and Rotorua in the North Island (the site of what is at present perhaps their highest population density in New Zealand). The central part of the North Island is ringed about with native forest and mountain ranges to the east, south and west. Yet by 1910 or earlier quail were already common in that district. Similarly it is difficult to account for the widespread and fairly dense quail population of the province of Marlborough in the South Island. There are no records of liberations being made nearer at hand than in Nelson province. However, it is possible that some of the very early unrecorded introductions by the then Canterbury Acclimatization Society were made far enough north to allow for colonization by the natural dispersion of this rather sedentary species. The spread of chukar (*Alectoris graeca*) from North Canterbury into Marlborough in recent years seems to be an analogous case (Williams 1950). Yet another example of colonization difficult to account for by natural spread alone, is that offered by the early presence in fair numbers of quail north of the Waitaki River in South Canterbury. Certainly banding studies in the United States have shown that California quail are occasionally capable of travelling over distances as great as thirty-one miles (Richardson 1941); but much of the country to be traversed in this way in New Zealand was originally most unsuitable as a quail habitat—being either under heavy rain forest or open grassland with but few shrubs or trees.

In the New Zealand area, California quail have also been introduced into the Chatham Islands at a date not yet traced but almost certainly before 1900. Here they are reported to be still present, apparently only in small numbers, on the main island. New Zealand-bred birds were exported to Fiji in 1917 and to Tonga in 1938. Introductions made to Norfolk Island in 1895 (where the birds have been reported to be plentiful and sometimes a pest) and to the Australian States of Victoria and Tasmania between the years of 1863 and 1874 (Ryan 1906) and New South Wales in 1944 (Tarr 1950) were, as far as can be ascertained, all of New Zealand stock. According to Tarr the species has so far failed to establish itself satisfactorily in Australia. California quail from New Zealand have even been sent successfully as far afield as the United Kingdom.

It has not been possible to trace whence, during the years between 1860 and 1870, the original birds were imported from which the present population is descended. Of the subspecies of *Lophortyx californica* listed by Peters (1934) or Ridgway and Friedmann (1946) only one has so far been identified from New Zealand—*L.c. brunnescens* (Ridgway and Friedmann, *op. cit.* and Fleming, pers. comm. 1951). It is not stated from what part of the country the specimens were obtained. Grinnell, who made the identifications, states that the same subspecies is the one present on Norfolk Island. If more than one subspecies has been introduced into New Zealand it is to be expected that hybrids will now be common since so much mixing of stock has taken place. A series of skins has been obtained to help settle this question, and further

reference will be made to this topic under the heading, Weights and Measurements.

GEOGRAPHICAL DISTRIBUTION

California quail are now to be found scattered throughout most of the North Island and occur in the South Island north and east of the Southern Alps to approximately as far as 45° 30′ S. except near the east coast where their range extends approximately to the mouth of the Clutha River. They are generally uncommon west of 169° E. in the southern part of this island.

FACTORS AFFECTING DISTRIBUTION

1. *Climate:* The species is tolerant of high rainfall, for it can be found in small numbers in places where the annual precipitation is as high as 100 inches—as for example near Collingwood at the northwestern extremity of the South Island. However, areas are favoured where the rainfall averages less than 60 inches a year. Temperature *per se* does not appear to influence distribution but there is a noticeable tendency for the species to avoid those localities where a mean annual temperature of less than 50° F. is accompanied by a mean annual rainfall in excess of 30 inches. It is this very combination, accentuated in its effect by the shortness of day in winter, that is probably the main cause of the repeated failures to acclimatize the California quail in Southland. Rainfall in excess of 100 inches a year is responsible for the absence of the bird in forest-cleared areas west of the Southern Alps.

2. *Altitude:* Quail have been found as high as 6,000 feet above sea-level but they are normally rare above about half that height. Naturally, climate is most important in limiting their vertical distribution and—as would be expected—they are found higher up in the warmer months.

3. *Vegetation:* Quail avoid two types of country—that under forest and that intensively farmed. Knowing this and what has been stated in the two previous paragraphs, one can in a very satisfactory way account for the present distribution of the species as far as numbers are concerned. However, between the two extremes of virgin forest and complete use of the land for agriculture it is obvious that there are types of vegetation quail prefer. These types are those which furnish the interspersion of cover and clear space that the birds require. There are two natural plant associations in New Zealand that do this—the manuka (*Leptospermum* spp.) heath and the tussock (*Poa* and *Festuca* spp.) grassland, and the latter only when it occurs with shrubs like wild irishman (*Discaria toumatou*) and creepers like lawyer (*Rubus* spp.) and *Muehlenbeckia* spp. The manuka association is more common in the North Island and the grasslands in the South, where at one time the latter supported a large population of the now-extinct native quail (*Coturnix novae-zealandiae*). In spite of settlement there are great expanses of heath that have been but little modified. On the other hand, not only has the native grassland been modified by the introduction of exotic trees and shrubs (so that a better and more widespread California quail habitat has resulted) and by burning and grazing, but entirely new habitats have

been created by the partial clearing of native forests, the invasion of wide river beds by such introduced weeds as gorse (*Ulex europaeus*), lupin (*Lupinus arboreus*) and broom (*Cystisus scoparius*), and the planting in many areas of great forests of exotic pines (*Pinus* spp.) criss-crossed with wide firebreaks. And everywhere where the ground is relatively clear, introduced herbs and grasses flourish and offer a ready supply of food.

4. *Land Use:* There is general agreement that California quail have diminished in numbers over the past sixty years—particularly in parts of the North Island. The introduction of mustelids that began in 1883, in what has since proved to be an unsuccessful attempt to control the rabbit (*Oryctolagus cuniculus*), is popularly regarded as the main cause. However, the part predators have played in the reduction of quail numbers has been (as will be shown later) almost certainly overestimated. Considering the North Island first, it must be remembered that much of what used to be good quail country was originally covered with the native podocarp forest and it was the partial clearing of the forest cover by fire and axe that created suitable habitats for quail. Destruction of the forest reached its peak in the decade after 1890, during which period 14,000 square miles were burnt or felled (Cumberland 1944). Since then, partially cleared land has suffered either one of two fates—it has been brought under intensive cultivation and so has been almost completely cleared and kept clean by grazing animals, or else it has been allowed to revert to second-growth forest. Either alternative eventually results in a habitat that becomes increasingly unsuitable for quail over large areas.

An illuminating example of this is afforded by the history of the California quail on Kapiti Island (now a bird sanctuary of some 5,000 acres three miles off the southwestern coast of the North Island). Before being declared a sanctuary about fifty years ago, the island had been used first as a whaling station and then as a sheep and cattle run. During this time goats (and rats, cats and Australian opossums) were let loose there; and soon the activities of the browsing animals together with the effects of occasional fires and clearing had modified the original forest association making it more dry and open (Cockayne 1907). In 1893, quail were liberated on the island (Wellington Acc. Soc. Ann. Rept. 1894) and fourteen years later Cockayne reported them to be "especially abundant." In the meantime most of the island was declared a sanctuary and the destruction of introduced mammalian pests begun. The only forest-browsing mammal now remaining in the sanctuary is the Australian opossum or phalanger (*Trichosurus vulpecula*) and cats are very rare, if not completely absent. The California quail population has decreased steadily (Wilkinson 1927, Stidolph 1948) until now the birds are scarce. It is hard to resist the conclusion that the gradual reversion of most of the island to its original dense plant association has been responsible for the decline in the quail population. At the same time European species and native species dwelling mainly on the forest floor have generally maintained their numbers.

In the South Island's grassland country, the initial improvement of it as far

as a quail habitat is concerned, brought about by tree and scrub planting has since been much offset by alterations made in the environment by long-continued intensive sheep-grazing and accelerated erosion brought on by a number of factors (Cumberland *op. cit.*). Both grazing and erosion have operated to diminish food and cover plants for quail over wide areas.

"Burning off" in early spring or summer, either for the purpose of clearing land of weeds such as gorse or for bringing on a growth of new tender grass for sheep and cattle, is still all too common a practice in New Zealand. Wherever it is carried out in quail country it causes high mortality in sitting hens or newly-hatched chicks as well as destroying nests.

PREDATION

The role played by predators in the life of a species is misunderstood by most sportsmen who are only too prone to blame any lack of success they may have in finding a game animal on the activities of predators that may, in reality, have little or nothing to do with the species in question. Common opinion notwithstanding, only four predators seem worthy of consideration in New Zealand as "natural enemies" of quail: feral cats, hedgehogs (*Erinaceus europaeus*) stoats (*Mustela erminea*) and ferret-polecats (*Putorius putorius*)—all of which have been introduced. Such effect as each exerts will vary with the locality and is probably greatest during and just after the nesting season. In the Nelson and Taupo districts hedgehogs are rare and predation is reported to be carried on primarily by cats; in Central Otago hedgehogs, cats and mustelids are all common and the last two are often encouraged to increase by being released from traps when caught, in the hope that greater numbers of them will aid in controlling the rabbits. In this district all these predators have been reliably reported as destroying eggs or birds (see also Wodzicki 1950). These are only qualitative considerations—the exact effect exerted by each predator still remains to be determined; but it is known that quail do occur in good numbers where all of these animals are present.

The harrier (*Circus approximans*), which has always been regarded by the sportsman as being a great threat to game birds, has recently been the subject of an investigation by Gurr who states in a personal communication that he has not found any evidence of game bird remains in the two to three hundred stomachs he has examined to date. Yet a rough calculation indicates that, since acclimatization activities began in this country, upwards of 200,000 of this species have been destroyed at the cost of many thousands of pounds paid in bounties—all without any direct evidence of serious predation by this hawk which, in these days at least, feeds to a great extent on carrion. In two years of observation of the California quail the author has not yet seen any of these birds attacked by the harrier. With its slow flight it is no match for their watchfulness and speed. This being the case, it is interesting to speculate on the reasons for the strong avoidance reaction quail exhibit in this hawk's presence—not only do they immediately fly to the nearest cover but they remain roosted there in silence sometimes for as long as a quarter of an hour after the

harrier has passed on out of sight. It seems very likely that this is an example of the operation of an "innate releasing mechanism" as demonstrated by Tinbergen (1939)—the birds' avoidance reaction being set in train by the outline of a hawk even though in the new environment the species of hawk supplying the stimulus is of no importance as a predator—a state of affairs very different from that existing in the original environment.

Two other possible quail predators—the European rat (*Rattus rattus*) and the New Zealand falcon (*Falco novaeseelandiae*) are uncommon in most upland game bird habitats.

OTHER CAUSES OF QUAIL MORTALITY

Poison: In those parts of the country where rabbits and quail are found together (and this applies particularly to Central Otago and Marlborough) the rabbit destruction campaigns are responsible for a number of quail deaths each year. The use of phosphorized grain is the main cause, but a good many birds are caught in rabbit traps and either have to be destroyed or are attacked and killed while in the traps by the various predators. Strychnined baits appear to cause but few deaths, and this observation is supported by the findings of Bryant (1925).

Hunting: As New Zealand's population increases so does hunting pressure on the various game animals. Not only are the areas of their ranges being gradually reduced but they are continually being made more accessible to a greater number of sportsmen. For example, in the Otago Acclimatization District alone (one of the many in the Dominion) the number of game bird shooting licenses issued increased from 26 in 1899 to 1,738 in 1949. Not included in these figures are the land-occupiers who are not required to take out licences for themselves or for one member of their family although they must otherwise abide by the game laws. In stating that hunting pressure has increased it is not automatically implied that "overshooting" occurs.

Accidents: Very little is known of quail deaths through this cause at present. Small numbers are killed throughout the country by being struck by motor vehicles.

Disease and Parasites: Of the hundreds of quail superficially examined during the past two years, only one showed obvious signs of illness. Otherwise all birds examined when alive or dead appeared to be in good condition. External parasites are rare and internal parasites are not particularly numerous. The following have been identified so far: *Heterakis* sp. (a nematode), *Hymenolepis* sp. (a tapeworm), *Eimeria acervulina* and *E. mitis* (coccidia) and, possibly, *Goniocotes* sp. (a louse). The last may have come from some chukar shipped in the same container.

Gross environmental changes: The part played by "burning off" has already been discussed. Wide climatic variations such as unusually heavy winter snowfalls (likely only in Marlborough and Otago) or particularly dry late springs or early summers when the young birds are hatching and the need for water is greatest, will adversely affect quail populations. (Grinnell 1927).

TYPES OF HABITAT

As most of the detailed study of the

California quail has been carried out in three rather different habitats—the grasslands of Central Otago and inland Marlborough, the heath or scrub (and sometimes forest) lands of Nelson, and the predominantly heath communities of parts of Taupo and the Bay of Plenty—it will often be necessary under the headings that follow to refer separately to findings obtained from each of these areas. Therefore they will now each be described in some detail.

Central Otago and Inland Marlborough: Except that mean annual rainfall is rather higher and mean annual temperature rather lower than in Central Otago (26.5 inches instead of usually less than 20 inches and 46° F. instead of 50° F.) there is such great similarity between these two areas that they can conveniently be considered as one. The originally predominant tussock cover of *Danthonia, Poa, Festuca,* and *Agrogyron* species has in most places been greatly impoverished by burning and grazing (Anon. 1944) and erosion of the thin skeletal soils is now a problem of great magnitude. In some of the more level areas, mats of scabweed (*Raoulia lutescens*) have halted the destruction for at least a time. Introduced grasses and herbs are now common and exotic trees and shrubs such as gorse, broom, lupin, briar (*Rosa eglanteria*), gooseberry (*Ribes grossularia*), willow (*Salix* spp.), poplar (*Populus nigra*), elder (*Sambucus nigra*) and especially pine, have supplemented the rather scanty growth of wild irishman, manuka, *Coprosma* spp. and various creepers and vines.

Wherever they are present (and this applies throughout New Zealand) the introduced pines—of which the most common is *Pinus radiata*—are most favoured for roosting cover. In the absence of pines, wild irishman or elder are the next choice where they occur, otherwise manuka, broom, gorse or briar suffice.

Ground cover is afforded by the native tussock grasses and the various shrubs and, in parts of Marlborough nearer the coast, bracken fern (*Pteridium esculentum*) and native flax (*Phormium tenax*) also serve the purpose.

Nesting cover is supplied by mixed native and introduced grasses and shrubs, crops of lucerne or clover, fallen rubbish, or even rocks and stones.

In spite of the rather imposing list of plants just given, there is little doubt that cover is the limiting factor over great expanses of Central Otago and Marlborough, for the degree of settlement is low, and the introduced trees and shrubs are concentrated about the homesteads in most cases. Water is usually ample as far as quail are concerned—springs, rivulets, seepage, dews or frosts occur even in the midst of summer, and water races are characteristic of the Otago landscape. In some parts of Central Otago "as many as 200 frosts per annum must be expected" (Garnier 1950). However, the generally low rainfall coupled with sheep grazing and a medium to heavy infestation of rabbits seriously limits the amount of browse available for quail in many localities—especially those distant from settlement.

Nelson District: Mean annual rainfall in the main quail-supporting areas varies—depending on the place—between thirty and fifty inches and the mean annual temperature near sea-level is about 55° F., so the climate is both warmer and wetter than in the habitat

just described. The original plant cover consisted of a coastal strip of scrub and heath with beech forest (*Nothofagus* spp.) dominant inland. Much of this has now been destroyed and as a result quail ranges have been created. In place of the rock outcrops, scabweed, sparse tussock and occasional trees and scrub of most of Central Otago and Marlborough, one finds a rolling landscape upon which are interspersed remnants of the original forest and patches of second-growth, large pine plantations, wide expanses of pastures of various kinds and—along the roads and on the hillsides—extensive thickets of broom, gorse, briar, bracken fern and blackberry (*Rubus fruticosus*). Because settlement and farming practice are well advanced, much land has become increasingly unfavourable for quail in this century through intensive cultivation and the increase of cattle and sheep. But wide areas still exist where, judging from numbers, the environment is much to the liking of quail. These areas usually consist either of the introduced pines associated with the naturalized shrubs and occasional clearings for cultivation, or else the manuka and bracken fern association—also with its accompanying naturalized shrubs—adjoining grazing or cultivated land. Quail occur too, about the small surviving remnants of the beech forest that are surrounded by settled country. Water in one form or another is always available.

Taupo, Rotorua and the Bay of Plenty: Those areas where quail are an important component of the avifauna, differ in many of their attributes—such as climate, soil, cover and degree of settlement—from quail country in Otago, Marlborough or Nelson. The overall mean annual rainfall is higher, ranging from about 45 inches at Taupo to about 55 inches or more further north in the vicinity of Rotorua and the coast, and the mean annual temperature is about 56° F. On the dry pumice soils of the centre of the North Island cover is thicker and more widespread than in either of the two habitats just described, and consists mainly of large expanses of manuka heath up to ten or more feet high with an understory of bracken fern. Since settlement, and in the Rotorua—Taupo district especially, introduced pines have become an important feature of the flora—forests extending for tens of thousands of acres in some places—but outside of these the pines are often small, being self-sown descendants of others destroyed in extensive fires of past years. Near townships briar, broom, lupin, gorse and blackberry sometimes make up as much as 25–30% of the total plant covering on previously-cleared land that has been allowed to go out of cultivation. Clearings supporting introduced herbs and grasses are common near habitations and along the edges of roads, but otherwise—around the shores of Lake Taupo particularly—the manuka-bracken association stretches for considerable distances without much interruption. With increase of cultivation of the manuka scrublands the quail habitat will be improved by the provision of more "edge land". Around the system of lakes in the Rotorua region podocarp forest was once dominant. Much of this has been cleared in the lower country and is now well farmed. Further north again and along the coast of the Bay of Plenty the heath association held sway, and still does, over large areas, but much of this land has been

cleared for dairy farming also. Succulent vegetation, streams, springs and the various forms of atmospheric moisture should afford a sufficient supply of water for quail at all times.

POPULATION DENSITY

Elton (1933), while commenting on the density of the numbers of animals, suggests that three types should be considered: (i) lowest density, which gives the number of animals occupying a given area that includes all kinds of habitats some of which would never be occupied at all; (ii) economic density, which expresses numbers in terms of the actual country inhabited and used for breeding; and (iii) highest density, which describes "local groupings or aggregations in density brought about by chance crowding for abundant food supply or by social habits leading to communal roosting and nesting." It is the economic density that is considered in this paper—being the one most suitable for the making of comparisons between populations in habitats sometimes situated in different countries.

Usually the taking of a census that is accurate is a matter of some difficulty—even in a small area; but a trustworthy one has probably been obtained for part of Cairnmuir Station, Central Otago, where coveys have now been under observation at various times for over a year. ("Station" is the Australasian term for a large property—usually of at least a thousand acres—used primarily for the grazing of sheep.) The property is situated on the banks of the Kawarau River near the town of Cromwell. Except in the immediate vicinity of the homestead, a great deal of the land is poor tussock country showing the ravages of fire and soil erosion not—it should be emphasized—attributable to any mismanagement by the present owner. Except where they have been planted since settlement, trees are rare on the hillsides and ridges, but along the banks of many of the local streams there are groves of manuka and wild irishman with occasional elders, willows and briars. Quail inhabit these areas in small but numerous coveys. Near to the house, and surrounded on all sides by the tussock land, are grass and lucerne paddocks. One large paddock of grass approximately one hundred and fifty yards square is planted on three sides with pines and on the fourth with a small orchard of assorted fruit trees. These pine trees are the roosting place for about 120 quail—a population that by all accounts does not vary markedly from year to year—and as no shooting is allowed the birds have become fairly tame and observation is therefore not as difficult as it is in places where the quail are shot at each season.

All birds in this fairly isolated habitat close to the house were counted with an accuracy of perhaps ±2% (except that an opportunity has not yet arisen to make the important post-breeding census), the areas occupied at various seasons accurately defined and particular coveys were often "labelled" by the presence of individually-marked birds.

In the winter of 1950 a total of 120 quail were occupying a range of thirty five acres—a density of 3.4 to the acre. By late spring (when nesting was just under way and the increase in cover supplied by the deciduous trees allowed the birds to roam further afield) the same number of birds were occupying the full summer range of one hundred

acres—a density now of 1.2 quail to the acre. These figures agree closely enough with those of Sumner (1935) who, "in a restricted area representing nearly ideal conditions" found that they "varied from 1.1 to 3.9 per acre according to the season of the year." Glading (1938) states that on the range studied by him the natural population densities varied seasonally from one quail to 1.59 acres to one per 2.27 acres; and Emlen (1939), in an apparently less favourable environment, found a density of one quail to the acre to apply the year round. Lack of cover was responsible for the continued dispersal in winter. In the Hawaiian Islands Schwartz and Schwartz (1950) state that densities vary from less than 15 to as many as 600 to the square mile but all islands were not censused during the same season. One could hardly expect any large part of Central Otago, consisting as it does of islands of quail populations separated by wide areas empty of the birds, to offer any better habitat than that at Cairnmuir, so perhaps a spring and fall economic density of one quail to the acre is as much as can be hoped for in this district. Management should aim at widening the quail range by judicious planting of food and cover types.

No quantitative population studies have yet been made in other parts of New Zealand but it may be said that in Marlborough similar conditions exist. In Nelson and Taupo favourable quail habitats are more common than in either Central Otago and Marlborough because the food supply is more plentiful and reliable and there is a greater abundance of suitable cover—especially in those localities where the manuka association or the pine forests are important components of the flora. One obtains the impression that around the shores of Lake Taupo and along the firebreaks in the Kaingaroa forests California quail are at present more uniformly abundant than anywhere else in New Zealand, and their good numbers in these situations have frequently been commented upon, (e.g. Weeks 1949 and Riney, pers. comm. 1951).

BREEDING

In early spring before courtship behaviour has begun (say, in late July or early August) a covey made up of almost every bird in the vicinity can be seen feeding in one, two, or at the most, three compact groups in almost precisely the same place each dusk. The following morning about sunrise the birds awake, descend from their roosting places, start feeding in a fairly close pack in the immediate vicinity and then, as the morning advances, begin to split up into the smaller covey formations that will remain intact during the day. These coveys then set out for the various preferred feeding and idling grounds. At first progress is rather slow and apparently rather aimless, but as the birds begin to fill their crops they begin to move with more purpose towards their goal. It is noticeable that a fairly well-defined route is followed and that the return journey is begun at much the same time each day. This time of return actually bears a relation to the time of sunset (i.e. light intensity) for it gets later with the onset of summer and becomes earlier as winter approaches. This regularity of route and time of movement of the great majority of coveys so far studied has been particularly noticeable in Central Otago,

and seems further evidence of the lack of suitable roosting cover for quail in this district. As the breeding season advances the number of birds in each covey diminishes, reaching a minimum in December. Thereafter the covey forming near the roosting place each night, begins to become larger again and continues to do so until by the beginning of April the cycle is virtually complete.

Pairing begins in late August or early September and at this time cocks start to show aggressive reactions on the near approach of others and the assembly call is given with increasing frequency. One also hears at this time the "cow!" call of unmated males. A cock has been seen trying to tread a hen as early as the 22nd of August in the South Island. Nesting starts at the beginning of October and goes on until as late as March. However, from November to January seems to be the busiest period.

At Cairnmuir, in one year, seven nests were available for observation. One of these was observed from the laying of the second egg until the hatching out and almost immediate destruction of the chicks by some predator. Another nest was followed from the laying of the second egg until the clutch was complete and the sitting bird killed by a young dog.

From general account and judging from those discovered, nests are usually just a hollow in the ground among vegetation or between rocks—anywhere in fact where there is some shelter, however slight. From the seven nests found, plus two that had been abandoned after only one egg had been laid, it may be assumed that overhead cover of some kind is also sought. Only a token attempt is made at lining the cavity and little more than a few straws and one or two feathers are ever found. In the

TABLE 1.—NESTS OF CALIFORNIA QUAIL AT CAIRNMUIR

Nest	Location	No. of eggs	Clutch completed	Hatched	Eggs Days	Eggs Hatched	Remarks
A.	Beneath some steel pipes	11	16 Nov.	7 Dec.	22	3	Remainder infertile
B.	In willow tree 2′ above ground	10	11 Nov.	23 Nov.	22	10	100% successful
C.	Under a rock 1′ from water race	14	?	30 Nov.	?	3	Egg taken daily by predator (9 in all)
D.	Under stones on bare hillside	10	1 Dec.	25 Dec.	24	..	Destroyed while hatching
E.	In thick grass near garden	10	5 Dec.	.....	..	..	Hen killed on 3rd. day of incubation
F.	Among thistles in lucerne field	11	7 Dec.	.....	..	..	Eggs taken by predator & hen killed
G.	In long grass near trees	16	.....	.....	..	..	Deserted before incubation advanced
H.	In long grass	1	.....	.....	..	..	Abandoned
I.	Among twigs beneath willow	1	.....	.....	..	..	Abandoned

following table, particulars of each nest observed are set out. Nests C., D. and E. will be dealt with at more length later.

The average clutch in the completed nests was just short of twelve eggs. This is in accord with reports received of the normal number of eggs in other nests. The average incubation time (including the day on which the last egg was laid) for three nests was approximately twenty-three days. This is in agreement with American figures. Of the nine nests, one was successful and two partially so. No figures are available from elsewhere in New Zealand to indicate whether or not this is a normal state of affairs but Glading (1938), in a much more intensive study under Californian conditions and with a much more representative sample, found seventeen successful or partially successful nests out of a total of ninety-six—half the percentage obtaining at Cairnmuir in 1949–50. However, the average brood size was 10.18 young compared with 5.3.

In spite of the fact that Nest C. was disturbed daily by some predator and an average of one egg a day stolen, the hen continued to sit on the dwindling clutch and finally hatched three chicks. From Stoddard's description of the predators of the bobwhite quail (1931) it seems likely that the animal concerned was a mustelid.

In the next table details are given of the laying schedules for nests D and E. Eggs were laid at the approximate rate of one every twenty-four hours although there was a definite tendency for the eggs to be laid slightly earlier each day, so that in each case the tenth egg was laid at a time somewhere between two and four hours earlier than the first had been laid ten days before. And it is obvious from the figures that the birds sat longer on the nest each day as the size of the clutch increased.

The male bird usually led the way to the nest and maintained strict watch on the way while the hen fed. When within a few yards of the nest the hen took the lead and entered leaving the cock on guard nearby. Here he would remain for a short time watching and feeding until at last rejoined by the hen when both would usually fly off. However, when she started to sit longer he would soon fly to rejoin one of the small coveys that still remained. By the time the ninth egg was laid the cock began to remain most of the day perched in a tree close to the nest. After some hours he would call the hen off for feeding. There were usually two or three feeding periods during the day, each lasting about half an hour and generally they were in the mid-morning or late afternoon. The hen was escorted back to the nest by the cock and this was

TABLE 2.—SITTING TIME AND CLUTCH SIZE OF CALIFORNIA QUAIL

Egg No.	1	2	3	4	5	6	7	8	9	10
		Min.	Min.	Min.	Min.	Min.	Hr.	Hr.	Hr.	Hr.
Nest D.		5	11	8	?	?	3.25	3.25	8.75 *	11 *
Nest E.		17	18	12	9	12	1.15	3.75	4.33 *	10.5 *

* First unbroken sitting. After one or two subsequent spells for feeding the hen returned to the nest for the night.

also done if the hen was flushed from the nest for any reason.

Two reports have been received of cock quail sitting on eggs: In the first instance the bird was one of a semi-tame pair; in the second the cock was a pet and it is said to have sat on a clutch after the hen had been killed and to have continued to sit until the eggs hatched. Accounts of these cases were supplied by the persons who claimed to have seen them happen. Emlen (1939) reports the case of a cock quail taking over incubation after his mate had been killed. However, the majority of cases reported of males sitting on eggs are probably examples of casual brooding rather than true incubation.

Mortality among chicks is high during the first month or so, as by late January during the last two years it has been unusual to see successful pairs with more than four young in attendance. In Central Otago the average clutch size has been even smaller at this time. In recent years the mortality rate among the juveniles must have continued high—an observation borne out by later shooting-diary and trapping figures. Such coveys as are seen in February are usually between fifteen and thirty strong which indicates that they are made up of from three to five family groups. As far as is known only one brood is produced by each pair each year. Those young appearing in February and March are almost certainly the result of pairs renesting after losing a first clutch.

SEX AND AGE RATIOS

The sex ratio calculated from 1,817 birds recorded from all parts of the country and taken over two years shows 133 males to 100 females. These records combine shooting, trapping and field counts. For 1,538 of these the age of the bird is also known, the figures referring to winter populations, as the quail were trapped or shot between April and July.

TABLE 3.—AGE AND THE SEX-RATIO IN CALIFORNIA QUAIL

Age Group	Cocks	Hens	Cocks/ 100 Hens
Unhatched	...	...	100 (?)
Immature	284	262	108
Adult	590	402	147

These results indicate that there is a higher mortality rate among hens than among cocks and that the difference arises between one winter and the following autumn. Similar findings have been described for the California quail by Emlen (1940) and Sumner, and for the bobwhite by Stoddard. We should expect, therefore, that as the age composition of a quail population becomes older the sex ratio will show an increasing preponderance of males. In the Southern Lakes Acclimatization District in 1949 the net replacement (i.e. the proportion of young birds to old in the total population) was 56% calculated from 230 birds shot, and the sex ratio was 129 males to 100 females in 508 birds recorded, including 278 field records; in 1950 the net replacement was 20% and the sex ratio 143 males to 100 females (from 628 birds). In a recent paper by Gurr (1951) the net replacement for 1948 as shown by his figures for the subsequent shooting season was 63% and the sex ratio 122 males to 100 females. The fall in net

replacement over three years is most marked.

In any one year sex ratios show a variation from place to place: In 1949 in Central Otago the ratio at Cairnmuir (found by field observation) was 132:: 100, whereas at Waitiri—some ten miles away—at the same time and by using the same method it was found to be 122:: 100. In 1950, and again in Central Otago, the ratio calculated from combined trapping and shooting figures in the vicinity of Alexandra was 118:: 100 (from 489 birds); whereas in the Lakes District by using the same methods it was found to be 143:: 100 (from 628 birds). It does not appear that results obtained from trapping or shooting consistently favour one sex or age group and this view is supported by Emlen (1940), Sumner and Stoddard. In the case of the sex ratio careful field observations should give a true picture and should be used as the standard of comparison.

Ageing has been carried out by using the primary coverts as the criterion and most of the results so far have come from Central Otago. In the three years (1949–51) for which there are records, in no part of this large area (which includes much of the Southern Lakes and Otago Acclimatization Districts) has replacement been satisfactory for it has varied with the place or year from 20% to 56%, and as in the case of the sex ratios these figures have been calculated from winter records.

FOOD

As in California (Glading 1940 and Sumner), quail feed casually throughout the day and are most active in this during the early part of the morning and the hour or so before roosting time. This general feeding pattern is altered by bad weather or by the presence of "natural enemies" such as the harrier. In Hawaii, Schwartz and Schwartz describe a rather different feeding rhythm in which there is only one intensive feeding period which begins in mid-afternoon and continues until the birds go to roost.

In the breeding season the feeding habits of the male are modified by the demands of courtship and nesting and the food intake becomes intermittent and limited. This state of affairs continues for most of the time of incubation (when the cock generally stays nearby while the hen is sitting) and for the early part of the period following the hatching of the chicks.

Sumner states that "the distances travelled during the day for food are slight (although) regions with a sparse food supply require more daily searching than do more favourable regions." In Central Otago quail move about freely during the day and have been seen to cover distances of from a quarter to half a mile to a preferred feeding and idling ground even though food and cover were available closer at hand. Sumner's further statement that "a food supply that is more than about fifty feet from cover is largely unavailable for the birds" is not generally applicable to such behaviour as has been observed in Central Otago.

In New Zealand the food habits of California quail have so far been analysed for only two seasons—winter and summer. It is realised, of course, that the local account will be incomplete until year-round food studies have been made for each major quail district.

During these two seasons, seeds of various kinds are the main item of diet, browse being mainly supplied by the leaves of *Trifolium* spp. and grasses. Insect material and grit together make up a very small proportion of the crop contents, the small quantity of the latter being correlated with the high percentage of seeds in the diet (Schwartz and Schwartz).

Some suggestions have been made that the competition offered for food by the ten or so established species of European passerines has a marked effect in governing quail numbers, but at present there is no proof that this is so. It is rather more likely that in those parts of the South Island where chukar and quail occupy much land in common there may be some such effect, for many of the foods are shared (Williams, 1951) and nesting requirements are very similar (Williams 1950). However, Moreland (1950) states that there appears to be no conflict between these two species in Washington.

Fifty-four quail crops have been analysed by the aggregate volume method (Martin, Gensch and Brown 1946) and, for the sake of easy comparison, Schwartz and Schwartz have been followed in assigning each food item to one of three arbitrary classes depending upon the percentage volume of the aggregate it occupies. Those making up 11% or more are placed in Class 1, those which fall between 1% and 11% belong to Class 2, and the rest comprise Class 3.

Plants from only five genera rank as Class 1 or 2 in both Hawaii and New Zealand, (*Trifolium*, *Bromus*, *Medicago*, *Cirsium* and *Stellaria*); only two genera are important both on the San Joaquin range (Glading 1940) and in New Zealand—*Trifolium* and *Poa;* and Sumner has three genera that occur in local material as well as in his own in volumes greater than 1%—*Trifolium*, *Bromus* and *Medicago*. In all four ranges, how ever, many foods occur in common.

The tables reflect not only the availability of the different foods in the New Zealand areas studied, but also demonstrate the differences existing between three countries and the adaptability of the California quail, since many of the local food items are indigenous. Of the 63 plant genera listed, approximately one-third contain species used for food that are native to New Zealand and four of these are in Classes 1 and 2.

Four crops of juvenile birds contained essentially the same food materials in much the same proportions as did those of adults taken from the same area.

WEIGHTS AND OTHER MEASUREMENTS

In this section the methods outlined by Simpson and Roe (1939) have been followed in making the statistical analyses, but it has been suggested (R. M. Williams, pers. comm.) that the usually accepted standard of significance of d/σ being greater than 3 is unnecessarily high in this particular case, and that under the conditions that exist of approximately equal variances and $N_1 + N_2$ being equal to 20 or more, d/σ being greater than 2 is a fairer test.

Specimens for weighing and measuring have been taken from the three main quail habitats described earlier, but the only population from which good samples of all the age and sex classes have been obtained is that of Central Otago. Therefore the results

TABLE 4.—SUMMER FOODS OF THE CALIFORNIA QUAIL IN THE TAUPO AREA

Species	Occurrence in range [1]	Food class	% of Crop volume	No. of occurrences
Cystisus scoparius	locally abundant	1	69.3	16
Rumex acetosella	abundant	1	12.7	10
Trifolium spp. (& leaves)	abundant	2	7.3	14
Vulpia spp.	abundant	2	1.4	6
Oxalis sp. (leaves)	common	2	1.1	3
**Haloragis uniflora*	common	3	0.9	5
Prunella vulgaris	common	3	0.5	7
Grasses (*Poa* sp. and	common to	3	0.5	5
Bromus mollis, (leaves)	locally abundant			
Lactuca virosa (leaves)	common	3	0.2	2
Acaena ovina	locally abundant	3	0.2	1
Senecio spp.	locally abundant	3	0.2	2
Compositae	....	3	0.2	4
Cerastium sp.	common	3	tr.	2
**Danthonia* sp.	common	3	tr.	2
Holcus lanatus	common	3	tr.	9
Alchemilla arvensis	common	3	tr.	12
Anthoxanthum odoratum	abundant	3	tr.	1
Crepis capillaris	abundant	3	tr.	2
Galium sp.	common	3	tr.	2
**Hydrocotyle novae-zealandiae*	abundant	3	tr.	2
Hypochoeris radicata	abundant	3	tr.	1
Juncus sp.	locally abundant	3	tr.	1
Myosotis sp.	common	3	tr.	1
**Pteridium esculentum*	abundant	3	tr.	1
Ranunculus repens	common	3	tr.	1
Rubus sp.	common	3	tr.	2
Silene gallica	abundant	3	tr.	3
Sonchus asper	common	3	tr.	1
Verbena officinalis	occasional	3	tr.	1
Veronica sp.	common	3	tr.	1
**Wahlenbergia* sp.	common	3	tr.	2
Miscellaneous and *unidentified plant material*	....	..	2.5	..
Animal material	....	3	0.2	3

Number of crops, 16.
All material seeds or fruits unless otherwise stated.
[1] Based upon Allan (1940) and Cheeseman (1925).
* Indigenous species.

obtained from it will be discussed in detail before going on to compare district with district and New Zealand birds with Californian birds.

By use of the usual statistical formulae it can be shown that there is no significant difference between the means of the body weights of the two age groups for each sex and they are shown combined in the last part of the table. Significant differences do exist between the means of the weights of the adult males and adult females and also between the means of the weights of immature males and immature females. These findings are interesting. They show that in this part of New Zealand at least, quail do not take a year to reach full adult weight. Sumner's claim that this length of time is required in California is not supported even by his own figures, as in some months his graph shows immature quail to have a greater weight than the adults of the

TABLE 5.—WINTER FOODS OF THE CALIFORNIA QUAIL IN THE MARLBOROUGH AREA

Species	Occurrence in range [1]	Food class	% of Crop volume	No. of occurrences
**Discaria toumatou*	common	1	32.7	13
Trifolium spp. (leaves)	locally abundant	1	14.3	14
Trifolium spp. (seeds)	locally abundant	1	12.2	7
Medicago lupulina (and leaves)	common	2	10.2	4
Ulex europaeus	locally abundant	2	9.2	5
Vicia spp.	common	1	12.1	5
Cirsium lanceolatum	common	2	1.0	8
**Carmichaelia* sp.	common	2	1.0	2
Bromus mollis	locally abundant	2	1.0	6
**Griselinia* sp.	locally common	3	0.6	1
Echium vulgare	locally abundant	3	0.6	4
Rosa eglanteria	locally abundant	3	0.4	1
Grasses (*Poa* spp. and	common to	3	0.4	5
**Agrostis muscosa* etc.—leaves)	locally abundant			
Urtica sp.	rare to common	3	0.2	1
Anagallis arvensis	common	3	0.2	1
Sagina procumbens	common	3	0.2	2
Myosotis sp.	common	3	tr.	3
Cerastium sp.	common	3	tr.	6
Carex sp.	locally common	3	tr.	1
Compositae	....	3	tr.	1
**Danthonia* sp.	common	3	tr.	1
Crepis capillaris	locally common	3	tr.	2
Daucus sp.	locally abundant	3	tr.	3
Holcus lanatus	common	3	tr.	1
**Hymenanthera* sp.	common (?)	3	tr.	2
Juncus sp.	locally abundant	3	tr.	1
Oxalis sp.	common	3	tr.	1
Prunella vulgaris	common	3	tr.	1
Ranunculus repens	common	3	tr.	1
Vicia spp.	common	3	tr.	5
Vulpia sp.	common	3	tr.	2
Miscellaneous and *unidentified plant material*	....	..	1.4	..
Animal material	....	3	0.2	2

Number of crops, 16.
All material seeds or fruits unless otherwise stated.
[1] Based upon Allan (1940) and Cheeseman (1925).
* Indigenous species.

same sex; and in those months when adults appear to be the heavier there are no indications that any of the differences shown are significant. Furthermore, some figures given by him for growth-rates of juveniles also seem to be inconsistent with his statement that young quail take a year to attain full adult weight—rather do they suggest that this is reached somewhere between three and four months after hatching, and this conclusion would appear to be supported by figures given by Stoddard for the bobwhite quail. As most of the new season's quail are hatched in New Zealand by the end of January it means that they are at least three months old when the hunting season opens early in May.

With the exception of body weight, no other external measurement made on quail from Central Otago shows any significant difference between the sexes (or between the age groups).

The following comments are necessary: "culmen" means "chord of the

TABLE 6.—WINTER FOODS OF THE CALIFORNIA QUAIL IN CENTRAL OTAGO

Species	Occurrence in range [1]	Food class	% of Crop volume	No. of occurrences
Sambucus nigra	common	1	29.4	8
Medicago spp. (seeds)	common	1	22.8	9
Trifolium spp. (mainly leaves)	locally abundant	1	16.5	14
Cirsium lanceolatum	common to locally abundant	2	4.8	14
Medicago spp. (leaves)	common	2	4.7	6
Euphorbia peplus	abundant	2	4.0	8
**Hymenanthera* spp.	common (?)	2	3.5	3
Stellaria spp. (leaves)	common to abundant	2	3.3	6
**Poa lindsayi* (leaves)	common	2	1.8	10
Myosotis spp.	common to abundant	2	1.2	5
Sagina procumbens	common	2	1.2	3
**Trisetum* sp. (leaves)	common to abundant	3	0.4	1
**Hydrocotyle novae-zealandiae*	abundant	3	0.4	3
Anagallis arvensis	common	3	0.4	4
Vulpia spp.	abundant	3	0.2	5
**Pimelea* sp.	?	3	0.2	2
Urtica sp.	locally common	3	0.2	7
Cerastium sp.	common	3	0.2	3
**Discaria toumatou*	abundant	3	0.2	11
**Myosurus novaezealandiae*	?	3	0.2	3
Vicia angustifolia	common	3	0.2	1
Compositae (flowers)	....	3	tr.	8
Aira caryophyllea	abundant	3	tr.	2
**Agrostis* spp.	common	3	tr.	4
Acaena sp. (& leaves)	locally abundant	3	tr.	4
Bromus mollis (leaves)	common to locally abundant	3	tr.	1
Carex spp.	locally common	3	tr.	4
Chenopodium album	abundant	3	tr.	3
**Coprosma* sp.	locally common	3	tr.	1
Cotula sp. (leaves)	common	3	tr.	2
Erodium sp.	common	3	tr.	6
Festuca rubra (leaves)	common	3	tr.	1
Geranium sp.	common	3	tr.	2
Holcus lanatus (leaves)	common	3	tr.	5
Lolium sp.	common	3	tr.	1
Oxalis spp. (& leaves)	common	3	tr.	4
Poa pratensis (leaves)	common	3	tr.	2
**Poa maniototo* (leaves)	common	3	tr.	2
Ranunculus sp.	occasional to common	3	tr.	1
Rosa eglanteria	locally abundant	3	tr.	1
Rumex acetosella	abundant	3	tr.	1
Miscellaneous and *unidentified plant material*	....	..	2.3	..
Animal material	....	3	0.2	3

Number of crops, 22.
All material seeds or fruits unless otherwise stated.
[1] Based upon Allan (1940) and Cheeseman (1925).
* Indigenous species.

exposed culmen", "tarsus" means "diagonal of the tarsus", "mid-toe and claw" means "diagonal of the mid-toe and claw taken when the bird is in the standing position" and "wing" means "chord of the closed wing". All specimens were taken in July.

Small numbers of quail from the Marlborough and Taupo districts have been measured for comparison with the

TABLE 7.—WINTER WEIGHTS OF CALIFORNIA QUAIL IN CENTRAL OTAGO

	Number weighed	Range	Mean	Coeff. of Variation	Standard Deviation	Standard error of Mean
Adult males	61	146–211 gms.	191.5 gm.	8.1	15.6	2.00
Adult females	41	150–209 gms.	185.0 gm.	7.5	13.8	2.16
Immature males	18	174–214 gms.	189.2 gm.	5.7	10.7	2.52
Immature females	13	158–194 gms.	178.4 gm.	7.2	12.8	3.55
Adult and Immature males	79	146–211 gms.	191.0 gm.	7.6	14.6	1.64
Adult and Immature females	54	150–209 gms.	183.4 gm.	7.5	13.8	1.88

TABLE 8.—BODY MEASUREMENTS OF CALIFORNIA QUAIL FROM CENTRAL OTAGO

	Sex	No. of Observns.	Range	Mean	Coeff. of Variation	Stand. Devn.	S.E. of Mean
CULMEN	Male	28	1.10–1.45 cms.	1.28	6.43	0.082	0.016
	Female	22	1.10–1.35 cms.	1.27	4.71	0.058	0.012
TARSUS	Male	28	3.25–4.00 cms.	3.55	4.45	0.158	0.030
	Female	22	3.20–3.80 cms.	3.58	5.71	0.204	0.044
MID-TOE & CLAW	Male	26	3.20–3.80 cms.	3.54	3.84	0.136	0.027
	Female	21	3.30–3.75 cms.	3.54	3.55	0.126	0.025
WING	Male	28	10.3–11.7 cms.	11.1	2.90	0.332	0.063
	Female	22	10.3–11.5 cms.	11.0	2.23	0.264	0.056

Otago population. With the exception of the tarsus in both sexes, there are no significant differences between the Otago and Marlborough populations; but a number of significant differences exist between the more extreme Taupo and Otago populations although weights are not comparable because they are those of different seasons. Within the Taupo population itself there are no significant

differences between the various means for the small number of birds in each age group, but there are significant differences between the sexes for the means of body weight and chord of the exposed culmen.

Apart from the seasonal weight differences, the Taupo population differs from that in Central Otago in culmen, tarsus and mid-toe and claw measurements and the differences are made more apparent if the two populations are compared by combining both sexes in an analysis.

There is no clear demonstration of the operation of Allen's rule, for although the culmen is shorter in the habitat with the lower mean temperature, the tarsus and mid-toe and claw are both longer than those of the birds living in the warmer climate.

When an attempt is made to compare local measurements with those given for the various subspecies by Ridgway and Friedmann, two serious difficulties are encountered: the latter give no statistical constants for their data, and in any case the majority of their measurements have obviously been made in different ways from those given in this paper, and only that for wing length seems comparable. Seasonal weights are not given—which is a pity—as in methods of weighing there can be little disagreement if the time of the year in which the birds are weighed is specified; and variations due to the operator are not likely to be a complicating factor.

TABLE 9.—WEIGHTS & MEASUREMENTS OF CALIFORNIA QUAIL FROM TAUPO

	Sex	No. of Observns.	Range	Mean	Coeff. of Variation	Stand. Dev.*	S.E. of Mean
WEIGHT **	Male	10	159–188 gms.	176.0	6.27	10.85	3.43
	Female	10	151–180 gms.	162.0	6.42	10.40	3.29
CULMEN	Male	10	1.30–1.47 cms.	1.39	4.25	0.059	0.019
	Female	10	1.20–1.42 cms.	1.31	4.51	0.059	0.019
TARSUS	Male	10	3.10–3.67 cms.	3.42	4.62	0.158	0.050
	Female	10	3.11–3.55 cms.	3.39	4.19	0.142	0.045
MID-TOE & CLAW	Male	10	3.00–3.61 cms.	3.33	6.76	0.225	0.071
	Female	10	2.93–3.53 cms.	3.39	6.05	0.205	0.065
WING	Male	10	10.6–11.3 cms.	11.0	2.64	0.290	0.092
	Female	10	10.6–11.2 cms.	10.8	2.11	0.228	0.072

* Corrected for the number of observations (i.e. σ^1).
** Summer weight—the specimens were taken in February.

(Perhaps the removal of crops before weighing—which was not done in this case—would be an added refinement.) However, some data on quail weights have been compiled from other sources and these are given with wing measurements in Table 10.

A series of 20 skins (11 from Taupo and 9 from Central Otago) were recently submitted to the Museum of Vertebrate Zoology, Berkeley, California, for identification and the following comments have since been received (F. A. Pitelka, pers. comm. 1952):

"In series, the specimens clearly fall within what is now called *L.c. californica* (formerly *L.c. vallicola*). Rather than suggesting the browner race of the California coast from Santa Cruz northward (*L.c. brunnescens*), your birds match variants only from the drier sections of the range of *L.c. californica*, such as the interior Sacramento Valley and the mountain ranges of southern California near Los Angeles."

From Table 10 it can be seen that the mean wing lengths of the *L.c. californica* from Davis, California and those from Central Otago show no likely significant differences; whereas the body weights differ considerably — perhaps significantly. This may be an example of the operation of Bergmann's law or it may be nothing more than an expression of nutritional differences at this time between the two populations.

ACKNOWLEDGMENTS

The author gratefully records his indebtedness to the following: Miss Ruth Mason and Mr. V. Zotov of the Botany Division of the Department of Scientific and Industrial Research for assistance in identifying crop contents; Mr. R. M. Williams of the Applied Mathematics Laboratory, D.S.I.R. for some advice in the statistical analysis; Mr. L. K. Whitten of the Wallaceville Animal Research Station for the identification of parasites; Mr. H. Holloway, the owner

TABLE 10.—BODY WEIGHTS & WING LENGTHS OF SOME RACES OF *L. californica*

Subspecies	Mean weight	Number weighed	Mean wing length **	Number measured
L.c. achrustera *	MF 150.6 gm.	32	M 110 mm. F 106 mm.	20 5
L.c. plumbea *	MF 157.7 gm.	57	M 107.3 mm. F 105.3 mm.	18 12
L.c. californica †	M 179 gm. F 171 " MF 175 "	39 25 64	M 110.6 mm. F 107.8 mm.	35 13
L.c. brunnescens *	M 187.4 gm. F 182.0 "	? ?	M 113.6 mm. F 110.0 mm.	25 11
California quail from Central Otago ††	M 190.4 gm. F 183.2 " MF 187.9 "	79 54 133	M 11.1 cm. F 11.0 cm.	28 22

* From Sumner (1935). The figures for *L.c. brunnescens* are for adults only and are autumn and winter weights.
** From Ridgway and Friedmann (1946), except New Zealand figures.
† From Emlen (1939). No ages given, winter weights.
†† Winter weights.

of Cairnmuir, for allowing long field studies on his property; and all those wildlife officers and private persons who have helped in many ways by offering specimens, information and their time so generously.

SUMMARY

California quail were introduced into New Zealand between the years 1862 and 1870. The species is now widespread in the North Island and in the east and north of the South Island. It also occurs in the Chatham Islands but not on Stewart Island. *L.c. californica*, and *L.c. brunnescens* have been identified from New Zealand.

The range extends from sea-level to 6000 feet in a climate that varies in mean annual temperature with the place, from 50° F. to 58° F. and in mean annual rainfall from about 13 inches to 100 inches. Wide expanses of native forest or intensively cultivated land are avoided. Two modified native plant associations are favoured—the *Leptospermum-Pteridium* heath and the *Poa-Fescue-Danthonia* grassland.

Predation and disease probably play only a small part in the control of numbers, but the method of land use is a most important factor.

Three California quail habitats are described. The "economic density" is about one quail to the acre.

The breeding season begins in September and continues until March but the peak of activity is between November and January. Age and sex ratios indicate poor breeding seasons recently in much of the South Island. There is a higher mortality rate among hens than among cocks.

Fifty-four crops have been analysed and from these over sixty plant species have been identified of which one third are endemic to New Zealand. Seed is the main item, browse being mostly made up of leaves of *Trifolium* species and grasses. Insect matter and grit occur in only small quantities.

The mean winter weight of quail in Central Otago is 191.0 grams for cocks and 183.4 grams for hens, and the difference between the sexes in both age classes (adult and immature) is significant. There is no significant difference between the means of the body weights of the two age groups in each sex.

Measurements are given for some external characteristics and the populations from three widely-separated habitats are compared. There is no clear-cut evidence for the operation of Allen's or Bergmann's laws within New Zealand. Comparisons between New Zealand and Californian populations can be only tentative because of the lack of sufficient information on the methods used in making the American measurements and the lack of statistical data for them.

LITERATURE CITED

ALLAN, H. H. 1940. A handbook of the naturalized flora of New Zealand. D. S. I. R. Bull. No. 83, Wellington, N. Z.

ANONYMOUS. 1944. Tackling high country "problem land" at Molesworth. Soil Conservation and Rivers Control Council, Bull. No. 2, Wellington, N. Z.

BRYANT, H. C. 1925. Quail poisoning experiments. Calif. Fish and Game, **11**: 149–154.

CHEESEMAN, T. F. 1925. Manual of the New Zealand flora. Wellington, N. Z.

COCKAYNE, L. 1907. Report on a botanical survey of Kapiti Island. Dept. of Lands, Wellington, N. Z.

CUMBERLAND, K. B. 1944. Soil erosion in New Zealand—A geographical reconnaissance. Wellington, N. Z.

DRUMMOND, J. 1906. On introduced birds. Trans. N. Z. Inst., **39**: 227–252.

ELTON, C. 1933. The ecology of animals. London.

EMLEN, J. T. 1939. Seasonal movements of a low-density Valley quail population. Jour. Wildl. Mgt., **3**: 118–130.

EMLEN, J. T. 1940. Sex and age ratio in survival of the California quail. Jour. Wildl. Mgt., **4**: 92–99.

GARNIER, B. J. 1950. New Zealand weather and climate. New Zealand Geographical Soc., Misc. series No. 1, Wellington, N. Z.

GLADING, B. 1938. Studies on the nesting cycle of the California valley quail in 1937. Calif. Fish and Game, **24**: 318–340.

GLADING, B., H. H. BISWELL and C. F. SMITH. 1940. Studies on the food of the California quail in 1937. Jour. Wildl. Mgt., **4**: 128–144.

GRINNELL, J. 1927. A critical factor in the existence of southwestern game birds. Science (n.s.), **65**: 528–529.

GURR, L. 1951. Age groups and sex ratio of the Californian quail in Central Otago in the 1948–49–50 shooting seasons. Notornis, **4**: 144–145.

HUTTON, F. W. 1869. The introduction of pheasants into Auckland Province. Trans. N. Z. Inst., **2**: 80.

MARTIN, A. C., R. H. GENSCH and C. P. BROWN. 1946. Alternate methods of upland gamebird food analysis. Jour. Wildl. Mgt., **10**: 8–12.

MORELAND, R. 1950. Success of chukar partridge in the State of Washington. Trans. No. Amer. Wildl. Conf. **15**: 399–407.

PETERS, J. L. 1934. Check list of birds of the world, Vol. **2**: 44–45. Harvard Univ. Press, Cambridge, Mass.

RICHARDSON, F. 1941. Results of the Southern California quail banding program. Calif. Fish and Game, **27**: 234–249.

RIDGWAY, R. and H. FRIEDMANN. 1946. The birds of North and Middle America, Vol. **10**: 275–291. U. S. Nat. Mus. Bull. No. 50. Washington, D. C.

RYAN, C. S. 1906. On European and other birds liberated in Victoria. Emu, **5**: 110–119.

SCHWARTZ, C. W. and E. R. SCHWARTZ. 1950. The California quail in Hawaii. Auk, **67**: 1–38.

SIMPSON, G. G. and A. ROE. 1939. Quantitative Zoology. New York.

STIDOLPH, R. H. D. 1948. Relative abundance of birds on Kapiti. N. Z. Bird Notes, **3**: 13–16.

STODDARD, H. L. 1931. The bobwhite quail, its habits, preservation and increase. New York.

SUMNER, E. L. 1935. A life history study of the California quail, with recommendations for conservation and management. Calif. Fish and Game, **21**: 167–256, 277–352.

TARR, H. E. 1950. The distribution of foreign birds in Australia. Emu, **49**: 189–198.

THOMSON, G. M. 1922. The naturalization of animals and plants in New Zealand. Univ. Press, Cambridge.

TINBERGEN, N. 1939. Why do birds behave as they do? Bird-Lore, **41**: 23–30.

WEEKS, M. F. 1949. Bird population of exotic forests, 1940–1948. N. Z. Bird Notes, **3**: 83–84.

WILKINSON, A. S. 1927. Birds of Kapiti Island. Emu, **26**: 237–258.

WILLIAMS, G. R. 1950. Chukar in New Zealand. New Zealand Science Review, **8**: 2–6.

———, 1951. Further notes on the chukar. Notornis, **4**: 151–157.

WODZICKI, K. A. 1950. Introduced mammals of New Zealand. D. S. I. R. Bull. no. 98, Wellington, N. Z.

Accepted for publication Dec. 4, 1951.

FACTORS AFFECTING THE SURVIVAL OF THE PLAINS MUSKRAT, *ONDATRA ZIBETHICA CINNAMOMINA*, IN OKLAHOMA

Bryan P. Glass [1]

Department of Zoology, Oklahoma A. & M. College, Stillwater, Okla.

The plains muskrat, *Ondatra zibethica cinnamomina*, is of special interest to those studying the ecological relationships of the species, for its range occupies the eastern part of the Great Plains, where conditions are marginal for its survival. Flowing and standing water are rare, especially in the southern plains, and years of scanty rainfall frequently occur. In the southern portion of this area, Oklahoma provides a suitable locale for studying the muskrat under unfavorable conditions.

Prior to the opening of the Oklahoma territory to homesteading during the closing decades of the nineteenth century, much of Oklahoma was virtually virgin land. Cultivated areas were small and scattered for the most part, and forests and grassland were unchanged from the primeval. Under these conditions the soil retained water from the brief and violent spring and summer rains, releasing it slowly through springs and seeps. If we are to believe existing reports concerning the nature of the land at the time of the great land rushes, springs were commonplace, and most streams were everflowing. In some favorable places there were even swampy or marshy spots. Hibbard (1942) records that prior to 1914 the Cimarron River in northwestern Oklahoma and adjacent parts of Kansas was a narrow, clear stream that was constantly flowing. The same was true of many smaller streams in the central and western parts of the state.

With the coming of the homesteaders the soil over most of the state was plowed and planted to crops, resulting in rapid surface runoff. Water storage in the soil declined, springs dried up, and most of the smaller streams became intermittent, fluctuating between flood conditions and dryness. Hibbard (*loc. cit.*) records how the Cimarron became transformed into a wide, meandering, sand-choked river in the course of a single flood in the year 1914. Lesser changes have occurred on other streams.

The availability of water during critical seasons has been materially altered. It is not intended to criticize happenings of the past, but merely to point out the changes in order to appreciate their bearing on the life history of the plains muskrat. Years of unwise land use reached their culmination in the drouth years of the early thirties. The impact of this disaster and the story of wholesale land abandonment and despair needs no repeating. Many schemes were initiated to aid in the recovery of the land. Most have involved direct or indirect measures for water control. It is not yet possible to evaluate fully the effect of contour farm-

[1] Contribution no. 182, Oklahoma A. & M. Department of Zoology. Research supported by Oklahoma A. & M. Research Foundation Project 24.

ing and other land-use practices as to their effect on water storage in the soil, and indirectly their control of stream flow. The construction of numerous large reservoirs and many thousands of farm ponds has had an immediate effect, and there are now many thousands of surface acres of water where none existed previously. Much of this acreage is potential muskrat habitat.

In the past in Oklahoma the muskrat has apparently been a stream-dweller. Prior to the last two decades, ponds and lakes had been virtually nonexistent. The only dependable water supply having been along the streams, muskrats tended to be restricted to them, and bank burrows were the only type of dwelling used. Muskrat populations declined with the decline of the stream habitat. Although exact information is lacking, fur records and impressions of longtime residents indicate that the drouth years mark the low point in the muskrat's struggle for survival. Recent records show a gradual increase since that time, if allowance is made for temporary declines during adverse seasons or periods of low market value. The observations here recorded were made in the vicinity of Stillwater, Oklahoma, near the eastern edge of the plains grasslands, where this vegetative type meets the hardwood forests. Much of the soil is red permian clay, typical of the arid southwestern region. The area is comparable to much of central Oklahoma, and observations made here should apply to similar places.

Recent development of large and small impoundments has made much new muskrat habitat available. Today muskrats are more often found in ponds, lakes, and strip-pits than along stream margins. Streams that maintain flow still harbor some animals, and provide routes of travel for many more, but the greater number occur in the new impoundments.

As a rule ponds and small lakes provide better habitat for muskrats than larger bodies of water. Smaller impoundments usually do not have floodgates, and ordinarily lose water mainly by evaporation. Large impoundments usually are equipped with outlet works, and the water levels vary from season to season through manipulation for flood control, power development, municipal water supply, and in some cases irrigation. Consequently much of the margin of these bodies of water is bare mudflat over which water floods and recedes at varying intervals. Under these circumstances food plants have difficulty in becoming established.

Much of the area of the larger lakes is not useful to muskrats, for the water is too deep to produce an abundance of the plants required. By contrast many smaller lakes and ponds are partly or completely filled with vegetation.

The general absence or scarcity of vegetation for building houses, and the fluctuation of water levels in most artificial impoundments make it necessary for muskrats to depend on bank burrows for dens. Muskrats will build houses if the requirements are met, but under prevailing conditions bank burrows are the rule. The length of shoreline, rather than the total acreage of water, is a factor in muskrat concentrations. The total amount of edge is much greater in ponds that in an equal acreage of a large lake, hence the smaller ponds can support a greater total population.

The practice of building fish-rearing

ponds below the dams of large impoundments is frequent in Oklahoma. These ordinarily have steep grass-covered sides and have depths varying from two to six feet. Unlimited supplies of clear or nearly clear water are usually available by siphon from the lake above. In such ponds food plants nearly always grow in profusion, and muskrats thrive.

The soils found in the vicinity of Stillwater usually erode rather readily under heavy use, so that the characteristics of each pond depend to a great extent on the intensity of land use on its watershed. As a rule poor soil conservation practices on cultivated land, or excessive grazing of pastures will cause erosion, with resultant silting of ponds. The silt particles tend to remain suspended making the water turbid to the extent that the pond remains barren of plant life indefinitely. The trampling of cattle also produces turbid conditions. By contrast ponds on well-managed areas are usually clear and support abundant plant growth. Silt washes into such ponds during the violent rains, but the particles usually precipitate within a few days. (Irwin and Stevenson, 1951). Such ponds, once established, tend to maintain their clarity indefinitely.

BEHAVIOR

Some behavior patterns seem to be responses to the southwestern environment, and these should be noted.

During the summer virtually all of the signs associated with the presence of muskrats disappear. Tracks are not often seen, defecation stations and feeding stations are not used, and very little evidence of cutting of food plants is seen. The latter is perhaps more apparent than real, for the writer has on numerous occasions found summer cuttings of a variety of plants, but in the profuseness of growth these may easily go undetected. This is especially so since muskrats utilize a variety of plants at this season, and no one food item seems to be heavily used.

The lack of evidence of activity in summer may be attributed partly to the fact that most ponds are full of water at this season. Usually by early fall the water has gone down somewhat, and by late September signs of activity become evident along the pond margins. Defecation stations are established, and often special locations are selected for feeding. To these places plant cuttings are brought, and the uneaten portions are discarded. These stations may consist of logs or planks at the water's edge, or merely a conveniently flat portion of the bank. Only once was a feeding shelter observed, such as is commonly seen in muskrat marshes. This one was constructed in midwinter, when a combination of burst siphon and leaking dike caused a pond to become drastically lowered. All den openings were exposed, and after the rats had extended entrance canals about 25 or 30 feet to keep pace with the receding water line they constructed a small shelter in the middle of the pond. *Najas guadalupensis* was used, the strands being draped over the exposed twigs of a sunken tree branch.

During the winter of 1946–47 the same circumstances served also to illustrate the way that these animals will alter their den openings in adapting them to abnormally low water levels. In the minnow ponds below the dam at Lake Carl Blackwell, a few miles west of Stillwater, the embankments were allowing considerable water to leak

away, but levels were maintained by a constant flow siphoned over the dam. When the siphon burst water levels quickly lowered, and the den openings, normally a foot or so below the surface, were exposed. As soon as one opening was exposed the animals would plug it with earth and trash, mainly dead stems of *Polygonum*, and open a new entrance at a lower level. When this in turn was exposed the whole process was repeated. Often openings at three levels could be detected. As the lowering water reached the foot of the embankment and receded across the bottom of the pond the muskrats would extend canals to the edge of the water. As the water receded further these would be extended, until at length some of them attained a length of approximately 30 feet. At this point it became impossible for the canals to be lowered deep enough to keep water in them. When this occurred the holes were usually abandoned.

In places where there are two or more adjoining ponds muskrats will frequently cross from one to another. If the intervening area is heavily sodded with grass the rats will use the same paths time after time, and well-defined trails result, indicating recent activity.

The unpredictable water supply and fluctuating water levels that characterize most impoundments in Oklahoma make this area a poor one for the growth of most plants usually regarded as suitable muskrat food. Cattails (*Typha latifolia* and *T. angustifolia*) do occur, but usually in small patches, and scattered, never in extensive areas such as occur in northern muskrat marshes. Rushes of the genus *Scirpus* are more uncommon. In certain impoundments the American Lotus (*Nelumbo pentapetala*) is well established. However the local people regard it as undesirable because of its tendency to choke entire bodies of water. Consequently its spread is not likely to be encouraged. In ponds where turbidity is absent, *Najas guadalupensis* often becomes extremely abundant. This plant will literally fill ponds whose depth is not too great. The plants usually root in water up to approximately 6 feet in depth, but the great length of the stems permit it to trail into much deeper water. In Oklahoma it remains green all winter. *Najas*, *Typha*, and *Nelumbo* are the principal aquatic plants available to muskrats for winter food, the former as green leafy vegetation, the latter two as starchy tubers.

Many other plants are available for food during the warmer parts of the year, and evidence of use has been noted in *Cyperus*, *Jussiaea*, *Ceratophyllum*, *Eleocharis*, *Polygonum* and *Potamogeton*. Other plants that may furnish food include *Dianthera*, *Juncus*, *Sagittaria*, and *Heteranthera*. Actual evidence of use of the latter group is lacking. They are less common, or are abundant only in very restricted localities. In this category should also be placed the introduced waterlily, *Nymphaea*. In some lily ponds muskrats have been known to eliminate these plants.

In ponds where only plants of these two groups occur muskrats may establish themselves and thrive until the onset of cool weather. If plants that provide winter food are not present, however, the first killing frost will cause the pond to be abandoned. This was observed in the fall of 1947 on a small lake north of Stillwater. On November 5 five occupied holes were observed in

the banks. Food plants in the vicinity consisted almost entirely of *Jussiaea* and *Cyperus*. Both showed evidence of heavy use. By December 1, when the area was visited a second time, frost had killed all of the plants in the vicinity. There was no evidence of muskrat activity, and the rats remained absent all winter.

Two species of exotic plants have come to occupy a significant position in the winter diet of the muskrat in Oklahoma. One is Johnson Grass, *Sorghum halepense*, a native of South Africa, which has become characteristic of field borders, roadsides, and stream banks. Where this grass occurs in proximity to water inhabited by muskrats the animals dig out the large rhizomes for food. In many places along streams this grass seems to be the sole item of food during the winter. It is probable that this introduced plant is responsible for the continued existence of muskrats along the streams in Oklahoma. The other is Bermuda Grass, *Cynodon dactylon*, a European grass that is widely used in Oklahoma for lawns, pasture, and as an erosion-resistant cover on dams and embankments. When used in the latter capacity it will spread to the water's edge, and may even trail into the pond itself. Muskrats resort to these places, especially in winter, and scratch out the rhizomes. Where this occurs over successive years the whole embankment may be undercut as much as 18 or 20 inches. Where burrows open into this undercut passageway they are doubly difficult to detect, especially if the bank is steep and there is no ditch along the bottom of the pond leading away from the opening.

In one of the fish-culture ponds at Lake Carl Blackwell in which it was difficult to maintain a full supply of water due to leakage, the margins had grown up with small cottonwood trees, *Populus deltoides*. When the leak was partially repaired in 1946 the water level was raised so that these trees stood in approximately three feet of water. Upon the lowering of the water from the failure of the siphon it was found that every tree in the pond had been completely stripped of bark from the water level to pond bottom. That this was not eaten of necessity is evident, for the whole pond border was sodded with Bermuda grass, and in the adjoining pond was an ample supply of *Najas*.

This pond provided an opportunity to observe the carnivorous tendencies of muskrats. When the water receded following the siphon failure raccoons dug about forty hibernating turtles, *Pseudemys scripta troosti*, out of the mud. As the water receded it was possible to keep track of successive finds, and to determine the manner of usage by both raccoons and muskrats. Only in one or two instances were the raccoons able to eviscerate the turtles completely. In other cases the limbs and heads were eaten off and the shell and its contents discarded. Muskrats would find the carcasses, gnaw them open, and feed on the contents. The shells were completely cleaned and chewed to varying extents.

Evidence of use of other animal food has not been observed by the writer. However, owners of one or two large ponds have related that in winter muskrats sometimes feed on large pond mussels, and their feeding stations may become piled with shells. The local forms of mussel that occur in ponds are

large and thin-shelled, *Uniomerus* and *Anodonta* being most common.

NUMBERS

No satisfactory method has been worked out for determining numbers of muskrats in ponds. House counts are not possible, and den counts give only an approximate answer. The use of the Snead live-trap (Snead, 1950) has not proven practicable because most ponds shelve rapidly into deep water and the rats do not ordinarily make ditches along the bottom leading away from the underwater entrances.

In the fish culture ponds below the dam at Lake Carl Blackwell an attempt was made to effect a cleanup count in the winter of 1947–48. The arrangement of these ponds is such that there are approximately 10.3 surface acres of water, and 8,000 feet of shoreline. In these ponds there were located 14 den sites, each possessing from one to three openings. This gives approximately one den per 750 feet. Trapping was carried on in November and December until several successive nights yielded no results. In this manner twelve muskrats were obtained, one per 667 feet of shore, or a little more than one rat per surface acre of water. Yost Lake, a lake north of Stillwater where conditions in most years are very favorable for muskrats, has an area of about 30 surface acres, of which a considerable amount (approximately one fifth) is grown up with cattail and lotus. The farmer who lives on land adjoining this lake traps muskrats every winter, and in average years takes between 30 and 40. This again amounts to just over one rat per acre. Both Yost Lake and the culture ponds are considered to be the best muskrat habitat seen in this study.

The winter of 1947–48 was one of extraordinary dryness, and ponds throughout this portion of Oklahoma suffered drastic reductions in stored water. Undoubtedly this subjected the animals to unusual predation from mink especially, although there is no concrete evidence of this. The dry spell was not broken until the middle of June, when the usual spring rains are nearly past. Thus the spring breeding season was seriously interfered with. The summer was unusually wet, which resulted in favorable conditions for muskrats. The effect of the severe conditions during the previous winter and spring were reflected in the experiences of Payne County trappers in the winter of 1948–49, most of whom gave up after a few nights of unsuccessful trapping, or after having caught nothing but half-grown kits. That this condition was a general one is indicated by the State Game and Fish Department report. In the years preceding, the annual take was in the neighborhood of 9,000–12,000 skins. The 1948–49 yield was only 7,000 though 1949–50 yielded over 11,000.

The writer has not had the opportunity of examining a large number of Oklahoma muskrats, and therefore has no data on sex ratios and age classes. Records kept on the condition of primeness of 31 skins taken in Payne County in 1947–48 show 24 young animals and 7 adults.

Attempts to verify mink predation on muskrats in the vicinity of Stillwater have met with no success. Analysis of 22 stomachs and 3 droppings taken in the winter of 1947–48 gave evidence of utilization of ten identifiable items, and

two samples of unidentified mammal hair (not muskrat). Listed in the order of descending frequency of occurrence these items consisted of crayfish (11), minnows (5), cotton rat (5), cottontail rabbit (3), insects (3), widgeon (2), unidentified hair (2), little short-tailed shrew (1), bobwhite (1), water snake (1), pocket gopher (1). Five stomachs were empty, or contained unidentifiable soft matter. However the writer did trap one mink in a trap set for muskrats in the entrance to a bank hole.

POND DAMAGE

Most local property-owners in the Stillwater area prefer not to have muskrats in their ponds. The objection is that they damage the pond banks, especially the dams, which may eventually require expensive repairs. Observations on a series of ponds north of Stillwater indicate that there are just grounds for this attitude. If the dam is sodded with Bermuda grass, its entire length at the water line may be undercut as much as 18 or 20 inches. When water levels decline, as they are certain to do sooner or later, the holes are altered to follow the retreating water line, resulting in additional disturbance of the embankment. The high winds that are characteristic of this area, causing considerable wave action, may aggravate erosion in these disturbed areas. If a hole is first constructed during a period of low water a subsequent rise will flood it completely, causing its occupants to enlarge and raise its interior, with the result that the dam becomes extensively excavated and contains numerous water-filled passages which aggravate erosion and weaken it structurally. If there are trees growing on the embankment muskrats will frequently dig tunnels which follow one or more of the roots, and may even make additional openings on the downstream face.

Another type of damage results from a dam having too little freeboard above maximum water level. In dams of this type the dens are too close to the surface, and use of the top as a road, footpath, or by livestock will cause breakthroughs.

Nagel (1945) has discussed means of preventing damage in ponds. Briefly these consist of dam construction with a freeboard of at least three feet, and with no greater than a 3–1 slope on the pond side of the dam. He also recommends that the dam be at least 22 feet in thickness at the water line. To this might be added that no trees be permitted to grow on the dam. Nagel also suggests that if the pond has no other steep banks except at the dam, selected parts of the pond margin may be cut back to create suitable places for den excavation. All of the instances of real damage seen near Stillwater have resulted from improper construction; the dams either being too narrow or having too little freeboard. Tree roots were to blame in one, with improper construction probably being a contributing factor.

In cases of severe damage riprapping of the dam face with a rock to a line about three feet below the lowest probable water level would undoubtedly prevent the muskrats from using the dam, but the cost of such an operation would be prohibitive. The specifications for farm pond dams provided by the U. S. Soil Conservation Service are so conservative that structures which follow them are not likely to be seriously affected by muskrat work. No serious

impairment has been observed in the Stillwater area where these specifications were followed.

SUMMARY

1. Muskrats have been favored in recent years in Oklahoma by the construction of numerous large and small impoundments.

2. The suitability of ponds for muskrats depends upon availability of food plants, which in turn depend upon lack of turbidity of the water and reasonably small fluctuations in water level.

3. Principal food plants during the critical winter months consist of *Najas*, *Typha*, *Nelumbo*, and two exotic species of grass, *Sorghum halepense* and *Cynodon dactylon*. Animal matter used for food consists of turtles and possibly freshwater pond mussels.

4. Bank burrows are used almost entirely for dens, only occasionally where water levels are nearly constant, and where abundant construction materials are available, will they build houses. Their digging in earthen dams makes muskrats unpopular with local people, but damage may be minimized by using proper construction methods.

LITERATURE CITED

HIBBARD, C. A. 1942. A new bog-lemming (*Synaptomys*) from Meade County, Kansas. Univ. Kansas Sci. Bull. **28** (pt. 1, no. 2): 25–35.

IRWIN, W. H. and J. H. STEVENSON. 1951. Physiochemical nature of clay turbidity with special reference to clarification and productivity of impounded waters. Bull. Okla. A. & M. Coll. **48**(4), Biol. Ser. No. 4. 54 pp.

NAGEL, W. O. 1945. Controlling muskrat damage in farm ponds. Missouri Cons. Comm. Circ. 136, 2 pp.

SNEAD, I. E. 1950. A family-type live trap, handling cage, and associated techniques for muskrats. Jour. Wildl. Mgt., **14**(1): 67–79. 1 pl.

Accepted for publication December 8, 1951.

THE EFFECTS OF ALDRIN ON BIRDS[1]

George Post

Wyoming Game and Fish Commission, Cheyenne, Wyoming

The Bureau of Entomology and Plant Quarantine, United States Department of Agriculture and the Wyoming Department of Agriculture carried out a grasshopper control program on approximately 300,000 acres of Wyoming range land during the summer of 1951. Aldrin (Compound 118) was used as the toxicant. Two ounces of Aldrin per gallon of kerosene were sprayed from aircraft at the rate of one gallon of insecticide to the acre.

The use of Toxaphene and Chlordane on bran for grasshopper control had previously been found to cause an increased mortality on game bird populations (Post, 1951 a). The Wyoming Game and Fish Commission was interested in knowing the possible deleterious effects of Aldrin spray on game birds. Prior to the actual spraying operations, a series of pheasants were given oral doses of known amounts of Aldrin. The results of this experiment showed Aldrin to be approximately five times more toxic to pheasants than Toxaphene and twelve and one-half times more toxic to pheasants than Chlordane. As each bird died, tissues were collected and analyzed for the presence of Aldrin. The results of these chemical analyses on tissues of birds known to have been killed by Aldrin showed that this method could be used as a diagnostic procedure on dead birds found in the sprayed areas.

Five hundred acres of land sprayed with Aldrin and one hundred acres of unsprayed (control) land were observed through the summer of 1951 to determine the effects of Aldrin spray on birds. The findings showed that the application of 2.0 ounces of Aldrin per acre, in kerosene, sprayed from aircraft on short grass ranges, caused little noticeable effect on wildlife. Excellent control of grasshoppers was obtained with applications of this concentration of Aldrin where populations of 6–7 grasshoppers per square yard prevailed. Most other insect species were killed also.

Laboratory Findings

A series of pheasants were given known quantities of Aldrin in order to determine the chronic oral toxicity of ring-necked pheasants and to develop a method for diagnosis of Aldrin poisoning.

Weighed quantities of Aldrin, ranging from one to eight milligrams per kilogram of body weight were given orally in gelatin capsules to each bird every day for ten consecutive days. Two birds were given one empty gelatin capsule per day for ten consecutive days as a control. As each bird died, it was necropsied. The brain, kidneys, liver, heart and lungs were removed and stored in waxed paper containers in the deep freeze until such a time as they could be analyzed. The results indicated that Aldrin is much more toxic to pheasants

[1] Contribution from Federal Aid in Wildlife Restoration Act Project, 28-R, Wyoming.

than Toxaphene or Chlordane. The critical dosage appeared to be at the four milligram per kilogram per day level. The death of one bird and the survival of the other at this level indicated 40 milligrams per kilogram of body weight to be the chronic L.D.50 level. All birds receiving larger amounts of Aldrin died (Table 1). One bird which received two milligrams per kilogram of body weight and two birds which received three milligrams per kilogram of body weight died. These individual cases were considered to be due to individual variations in the susceptibility of the bird to toxic materials such as Aldrin. One of the birds which was given three milligrams per kilogram of body weight died after receiving only three doses, but death was due to trauma. Tissues from the dead birds consistently showed the presence of Aldrin. Neither time of death nor the total amount of Aldrin given seemed to have any bearing on the concentration of the insecticide in the tissue. The brains of all birds contained the highest concentration of Aldrin ranging from nine to sixty-five parts per million, the kidneys from four to nine, the livers from two to six, and the heart-lung composite from two to ten parts per million (Table 1). All organs were analyzed separately except the heart and lungs. The lungs were combined with the heart because they were so small. Skeletal muscle was found to contain only traces of Aldrin.

The analytical procedure used for this work was the method of Danish and Lidov (1950). The extraction procedure was the method of Borgmann, Dahm and Kitselman (1950). These methods proved satisfactory and specific for Aldrin. Normal pheasant tissues showed color reactions ranging from 0.1 p.p.m. for brain tissues to 0.3 p.p.m. for liver and kidney tissues. The organs from one bird were stored in the deep freeze

TABLE 1.—TOXICITY AND CHEMICAL ANALYSIS OF ALDRIN ON PHEASANTS

Dosage Mg/Kg per day	Total amount (Kg)	Time of Death*	Chemical Analysis in ppm Aldrin			
			Brain	Liver	Kidneys	Heart-Lung
0	0.0	Remains alive	..	..	..	..
0	0.0	Remains alive	..	..	..	..
1	11.1	Remains alive	..	..	..	..
1	10.9	Remains alive	..	..	..	..
2	23.6	21 days	9	2	4	4
2	20.1	Remains alive	..	..	..	..
3	12.5	3 days**	11	trace	5	2
3	41.9	15 days	18	3	5	4
4	53.6	Remains alive	..	..	..	..
4	47.0	12 days	32	6	8	7
5	51.3	58 days	19	2	11	6
5	46.6	7 days	15	4	5	2
6	70.8	17 days	65	4	7	10
6	65.7	20 days	13	3	4	5
7	88.2	25 days	25	3	8	4
7	79.5	21 days	30	3	6	5
8	91.2	18 days	17	4	9	5
8	100.8	32 days	20	3	9	4

* Designates time of death from the first dose.
** This bird was pecked by the other birds.

for two months and from another bird for three months with no appreciable change in Aldrin concentration during storage.

The only consistent gross pathology noted on the dead birds was in the liver and brain. The liver was very dark in color and the brain appeared congested with occasional, small subdural hemorrhages. The kidneys were occasionally darkened but not swollen. The heart was firm and occasionally quite cyanotic. The lungs, intestinal tract and spleen were usually normal in appearance. The body was emaciated. The weight loss ranged from 16 to 41 per cent. Generally speaking, birds became ill three to five days before death and would not eat or drink during this period of time.

The female pheasants used for the toxicity experiment with Aldrin were all producing eggs. Within four days after the initial dose was given, all birds receiving Aldrin had ceased egg production. No eggs were produced by these birds throughout the remainder of the experiment. The experiment began on May 17, 1951 and was completed by September 1, 1951. The two female pheasants used as control birds continually produced eggs throughout May and most of June. As birds died, the ovaries were found to be atrophied and there were no maturing ova.

RESULTS OF FIELD OBSERVATIONS

Five plots of approximately one hundred acres each were set up within a 12,000 acre sprayed area. These plots were searched systematically twice each week throughout the summer. One plot of approximately one hundred acres, completely removed from the sprayed area, was set aside as a control plot and was searched in the same manner as the sprayed plots for the same period of time. All plots were on sagebrush-short grass range land and all had springs or seeps as water supply for birds. The intermittent stream bottoms had a few deciduous trees and brush type vegetation. The remaining portions of the plots had sagebrush of varying density. There was a good grass cover throughout all plots. All plots carried sage grouse and sharp-tailed grouse. Two of the sprayed plots and the control plot carried Hungarian partridge. One sprayed plot had a small permanent reservoir on which was one merganser. All plots carried meadowlarks, vesper sparrows, lark buntings, solitaires and mourning doves. There were many hawks and a few golden eagles and owls. There were many species of rodents. Most plots carried raccoons. Bullsnakes, blue racers and rattlesnakes occurred on all plots.

The six plots were searched every three or four days. The number of living and dead game birds were recorded each time a plot was searched. The average number of game birds seen in one day's observation was considered to be the census figure. This was believed to be the best means of determining the number of birds in residence throughout the summer. A census of living song and predatory birds was not made.

Seventeen dead game birds were found on 500 acres of Aldrin-sprayed land. Nine sage grouse and one sharp-tailed grouse were found which had been eaten by predators. Six illegally killed sage grouse were found. The only remains of the latter were the viscera, head, wings, feet, skin and feathers. One was an adult female whose head

had been pulled off and the carcass abandoned beside the above-mentioned portions of two juveniles. One female merganser was found dead on a small permanent reservoir two days after the reservoir had been sprayed. Two game birds which had been eaten by predators, were found on the 100-acre control plot. Thus eleven game birds (the six illegally killed sage grouse are disregarded) were found dead on the 500 acres of sprayed land, whereas two game birds were found dead on the 100-acres of control land. This would seem to indicate that there was no appreciable deviation of mortality on the sprayed acreage from the normal mortality noted in the control acreage. The game bird population per acre on both sprayed and control acreage was comparable.

The case of the merganser found dead on the permanent reservoir merits additional discussion. This bird was observed on the reservoir the day before the reservoir was sprayed. At that time the bird appeared to be healthy. It was the only duck on the reservoir and was the only one seen on the water throughout the summer. Two days after the area had been sprayed, this bird was found dead. Analysis of tissue showed the presence of Aldrin. The brain had a concentration of 31 p.p.m. of Aldrin, the kidney a concentration of 24 p.p.m. and the liver a concentration of 4 p.p.m. These results compare favorably with those on pheasants in Table 1 and show that death was no doubt due to Aldrin poisoning.

Ten additional birds were found which had been eaten by predators on the sprayed acreage. These included three meadowlarks, one solitaire, four magpies and two nighthawks. One meadowlark and one solitaire were found which had been eaten by predators on the control acreage.

One catbird was found ill in the sprayed area approximately one-half mile from the perimeter of one of the searched plots. This bird was kept over night and died the next morning. Analysis of the combined brain, kidneys, liver, heart and lungs showed a concentration of 63 p.p.m. of Aldrin. There is little doubt but what this concentration was responsible for the death of this bird.

The only other noticeable effect on song birds was their movement from sprayed areas apparently in search of insect food. Three of the sprayed plots were set up before spraying began. At that time there were many song birds throughout. The first nesting was complete and the young were flying. Two days after the plots were sprayed, song birds began to leave the area. Five days after spraying, only an occasional song bird was seen and most of these were in their second nesting attempts. One meadowlark nest, one vesper sparrow nest, one mourning dove nest and one solitaire nest were observed after the spraying. All four of these nesting attempts were unsuccessful. The exact reason is not known, but decreased food supplies may have been responsible. Song birds moved back into the plots as insects began to reappear. Game birds did not move out of the sprayed plots to any great extent.

Analysis of poisoned grasshoppers collected the first and second day following spraying showed the presence of 3.4 micrograms of Aldrin in 100 grams of grasshoppers, on a live weight basis. Freshly killed grasshoppers were found

to contain 28.7 milligrams of Toxaphene per 100 grams of grasshoppers on the live weight basis (Post 1951 b). Approximately 8,500 times more Toxaphene than Aldrin was present in 100 grams of grasshoppers. A comparison of the toxicity of Toxaphene and Aldrin to pheasants does not show this variation. The acute critical toxicity of Toxaphene to pheasants was at the 200-milligram per kilogram of body weight level, whereas the chronic critical toxicity to Aldrin was at the 40-milligram per kilogram of body weight level. The small amounts of Aldrin present in poisoned grasshoppers tend to rule out insects as a means of birds obtaining a lethal quantity as a result of eating them. The two birds found dead because of Aldrin poisoning were probably victims of contact poisoning and not oral poisoning. These findings could account for the increased bird losses when Toxaphene was used as compared with the negligible bird loss when Aldrin was used.

Two ounces of Aldrin per acre was highly toxic to insects. There was an average of 6–7 grasshoppers per square yard, as well as many other species of insects in the sprayed plots. Nearly all insects were killed by the application of Aldrin, including ants, beetles, honey bees and many other flying insects.

CONCLUSIONS

The use of two ounces of Aldrin per acre in kerosene for grasshopper control from aircraft did not cause any noticeable deleterious effects to birds found on short grass ranges in central Wyoming. The mortality to bird life on the sprayed plots was not appreciably different from the normal mortality on a control plot. The effects of this spray on waterfowl may show variations from these findings. The use of Aldrin in kerosene spray over water is much different. Waterfowl are in contact with concentrations of Aldrin floating in the oil on the surface of the water. Only one resident duck was noted throughout the plots. The fact that this duck was killed by Aldrin poisoning may tend to show the possibility of duck losses if Aldrin in kerosene is used over waterfowl habitats. Lethal effects on other birds are no doubt similar. Only those birds coming in contact with lethal quantities of Aldrin under the spray would be effected. It would be possible for a bird, moving about while spraying operations are being accomplished, to receive the spray many times.

A factor that should be considered before spraying activities are initiated in the spring is the progress of the nesting activities of birds. Apparently small quantities of Aldrin cause a cessation of egg production in pheasants, and this same effect may manifest itself in other birds.

SUMMARY

1. The chronic oral toxicity of Aldrin to pheasants was found to be at the four milligram per kilogram of body weight level when this amount was given for ten consecutive days. The critical oral toxicity, therefore, was found to be at the forty milligram per kilogram of body weight level.

2. A method for diagnosis of Aldrin poisoning in birds was devised from the chemical analysis of tissues from birds known to have been killed by Aldrin. The presence of Aldrin in the brain, kidneys, liver, heart and lungs was con-

sidered to be evidence of Aldrin poisoning. The time of death following dosage or the total amount of Aldrin given seemed to have little bearing on the concentration of the insecticide in the tissues.

3. Grasshopper control measures in Wyoming during 1951 consisted of spraying two ounces of Aldrin in kerosene spray per acre. Five hundred acres of sprayed land and one hundred acres of unsprayed (control) land were studied during the summer in an effort to determine possible deleterious effects of the toxicant to wildlife. There was no appreciable difference in bird mortality on the five hundred sprayed acres as compared with the one hundred unsprayed acres.

4. One merganser and one catbird were found dead in the sprayed areas. Chemical analysis of the organs from these two birds showed the presence of Aldrin. These two birds were probably victims of contact poisoning with Aldrin.

5. Excellent control on 6–7 grasshoppers per square yard was accomplished. Many other insect species were killed. Aldrin killed grasshoppers were found to contain 3.4 micrograms of Aldrin per 100 grams of grasshoppers on the live weight basis.

LITERATURE CITED

BORGMANN, A. R., P. A. DAHM and C. H. KITSELMAN. 1950. Toxicological studies of Aldrin to laboratory animals. Exhibit No. 1218: Julius Hyman and Co.

DANISH, A. A. and R. E. LIDOV. 1950. Colorimetric method for estimating small amounts of Aldrin (Compound 118). Analytical Chem., **22**(5): 702.

POST, G. 1951a. Effects of Toxaphene and Chlordane on certain game birds. Jour. Wildl. Mgt., **15**(4): 381–386.

POST, G. 1951b. The effects of Toxaphene and Chlordane insecticides on birds. Wyoming Federal Aid Project 28-R, April 15, 1951.

Accepted for publication January 2, 1952.

BOBWHITE MOBILITY IN CENTRAL MISSOURI [1]

Dean A. Murphy

Missouri Conservation Commission, Columbia, Missouri

and

Thomas S. Baskett

Missouri Cooperative Wildlife Research Unit, University of Missouri, Columbia, Missouri

The early studies of bobwhite quail mobility in the Southeast by Stoddard (1931) and in Wisconsin by Errington (1933) led to the view that the species is quite sedentary, at least in those regions. This view was held by Leopold (1933) who summarized the earlier findings, stating that probably the bobwhite is the least mobile species of American game, and that nearly half the quail spend their life-spans within a quarter-mile of their birthplaces, while few ever wander more than a mile.

More recent work in Texas (Lehmann, 1946), and in Wisconsin (Buss, Mattison, and Kozlik, 1947; Thompson and Mattison, 1950) has indicated that quail populations are considerably more mobile in these states than in the Southeast. In Texas, wholesale movements to and from certain study areas were suspected; shifting was thought to occur both in summer, following failure of early nests, and in winter. In the Texas study, more than half the quail evidently moved decidedly more than a quarter-mile from their birthplaces. In Wisconsin, ingress to and egress from study areas were noted, especially in spring; quail movements in spring averaged a mile.

Duck (1943) found pronounced movements of quail from upland summer range to bottomlands and dunes during winter in northwest Oklahoma. In this same region, Davison (in Duck, 1943) reported similar movements involving distances of from 3 to 26 miles. In central Missouri, Murray (1948) ascribed changes in the quail populations of two study areas to ingress and egress. The movements occurred between April and June, but the distances involved were not known.

Because of the differences in results of mobility studies conducted at widely separated points in the bobwhite's range, and a lack of published data on movements of banded quail near the center of the range, the investigation reported here was begun.

This investigation was conducted from July, 1949 until June, 1951 on

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation and University of Missouri cooperating.

The writers are indebted to the following persons: the late Dr. Rudolf Bennitt, for advice; Dr. William H. Elder, for advice and criticism of the manuscript; and Messrs. John Lewis and Perry C. Smith for aid in the field.

Acknowledgment is due the Edward K. Love Foundation, for a fellowship granted the senior author.

the Ashland Wildlife Research Area, located near Ashland, Missouri, in southeastern Boone County. During the first year, while the study was in its formative stage, much field time was contributed by both writers; however, most of the data were collected by Murphy during his residence on the area in the second year of the study.

The Ashland Wildlife Area comprises 2,240 acres of submarginal land purchased by the Resettlement Administration in the 1930's and later leased to the University of Missouri. The area has three large ridges running generally north and south, separated by the deep valleys of two streams (Fig. 2). The valleys and parts of the ridges are forested with cut-over oak-hickory woods of various ages. The ridge-tops are mostly abandoned fields which have undergone severe sheet erosion. They are vegetated by plants characteristic of old-field succession in the region, as described by Drew (1942); the major communities are dominated by annual weeds, goldenrod-aster, broomsedge, and sassafras-persimmon. In addition, there are dense stands of sericea lespedeza and several plantations of coniferous and deciduous trees. Food plants of importance to quail are Korean lespedeza, ragweeds, sumac, pokeberry, and wild grape. Escape cover is provided by blackberry, coralberry, and several plantings of multiflora rose. Cultivation is confined to a bottomland field in the southeast corner of the area and three small fields in the north-central part.

In general, the area is not highest-quality quail range. Cover seems adequate, but food may be insufficient during winter. Late winter quail populations approximated one bird to ten acres; the population was confined largely to the ridge-tops. The north-central part of the area carried much higher densities, approaching one bird to the acre in the fall. Because of the hilly terrain and abundant cover, censusing the area was very difficult.

METHODS

For spring and summer trapping, a modified version of the "cock-and-hen" trap described by Stoddard (1931) was employed. This version differed from the Stoddard trap in that the sides, doors, and partitions were constructed of welded-wire poultry run flooring (one-inch by two-inch mesh) instead of small-mesh hardware cloth; the length of the sides was reduced from 36 inches to 32 inches; no wooden framing was used, the sides being wired together so the traps could be collapsed and carried in a passenger car.

The procedure followed in spring and summer trapping included driving about the area shortly after sunrise and setting a trap baited with a decoy female near several whistling males. If the decoy did not begin calling, the investigator hid nearby and attracted males to the trap by imitating the female's call. After several males had been caught, the trap was moved and the procedure repeated at other sites.

Later in the morning, several traps were set near whistling males. These traps were left in position the remainder of the day and were visited at least every three hours. The investigator always imitated the female call several times before leaving the trap; this practice stimulated nearby males to call, which in turn stimulated the decoy females.

At first, systematic coverage of the area was attempted in summer trapping. However, it became apparent that it was useless to set traps where no males were calling, and the system of "following" the whistlers described above was adopted. Traps were moved at least every two days to avoid possible holding of males at the same sites. Most of the spring and summer trapping was done in the north-central portion of the study area because birds were plentiful there; however, in order to secure data for mobile individuals, trips were taken almost daily to the periphery of the area to locate and trap quail. In addition, at least one trip per week was made on roads leading away from the area, in attempts to locate marked birds.

In fall and winter, traps were baited with a mixture of cracked corn and small grains; "cock-and-hen" traps and "government sparrow traps" (Lincoln, 1947) were employed. Of these two, the "cock-and-hen" trap was generally more successful. Pre-baiting of trap-sites was seldom done. Drive-trapping was attempted, but was impractical on this area because of the rough terrain and dense cover.

Generally, coveys were located and their ranges fairly well determined before trapping was started. Traps set after only one flushing of a covey were usually not successful.

Postcards were mailed to 200 rural boxholders in the vicinity of the area, requesting information from any marked birds shot on their farms; these yielded only one record. The Ashland Research Area is a refuge.

All trapped quail were marked with serially numbered metal leg bands, colored celluloid bands, and plastic neck tags. Combinations of colored and metal bands permitted field identification of individual birds. The plastic tags were "bow ties" developed by Wint (1951); each consisted of a strip of Koroseal attached to the nape of the quail's neck by a Michel wound clip. Neck tags of five different colors were used to show the portion of the study area in which the bird was marked. In general, the colored bands were difficult to "read" with accuracy in the field; the plastic tags were more easily seen and were more useful, particularly in identifying coveys. Most of the data were secured through retrapping, and the numbered metal bands alone would usually have sufficed.

The results obtained are subject to at least three qualifications: (1) the grain bait and decoy females may have influenced movement; (2) chances of retrapping the more sedentary birds were better than of retrapping the highly mobile ones; and (3) the returns may represent minimum distances because the birds may have wandered beyond the trap locations and returned before being retrapped. The use of drive-trapping would have removed the first qualification, but the others are inherent in most studies of this type.

During the investigation, 402 quail were trapped; 136 of these birds gave a total of 555 records of movements.

SUMMER MOVEMENTS

Summer was considered to be the period between June 1 and September 1; at the beginning of this period, covey dissolution was complete and at the end, mating activity had virtually ceased.

During the summer of 1951, 62 quail

were trapped at least once; of these, 32 individuals (30 males and two females) gave 119 records of movement.

Four males gave records of movement within a single day: they moved 564, 248, 165, and 153 yards, respectively. (All distances were measured between trap-sites plotted on aerial photographs.)

Fourteen records of movement from one day to the next were secured. None of the records showed movement exceeding a half-mile, and nine of the 14 records were of moves of less than a quarter-mile.

We found no reports of day-to-day summer movements of bobwhites in the literature, although Stoddard may have obtained such data. For the valley quail (*Lophortyx californica vallicola*) Emlen (1939) found the unmated males to be sedentary or nomadic; the nomadic males wandered extensively, sometimes as much as a mile in a day. Our data, though limited, indicate lesser daily movements in summer for the bobwhite.

Movement data for the entire summer are summarized in Table 1. Tabulation of distances between the two most widely separated summer trap-sites for each individual gave results almost identical with those shown in Table 1 wherein dispersal from the first summer trap-sites is tabulated.

These records indicate that bobwhites in Missouri are not extremely mobile in the summer, for 88 per cent of the individuals giving records remained within a half-mile of the first summer trap sites. The four males moving in excess of this distance were trapped about 1730, 1180, 1300, and 2200 yards from the first trap-sites.

The use of decoy females in trapping may have influenced these findings, but frequent moving of the traps, breaks in continuity of trapping in each part of the area, and the failure of the decoy female to call once a male was trapped, all gave males ample opportunity for uninfluenced movement.

The summer movements of seven birds are shown in the diagrams (Fig. 1). These diagrams show accurately the direction and extent of movements for each individual, but do not show the frequent overlapping of summer ranges.

The tendency for the diagrams of summer movements of the males (presumably unmated) to form closed figures indicates that the birds were not merely drifting, but that they had some geographic orientation. Emlen (1939) found that even nomadic unmated male valley quail recognized some regional boundaries.

Whether the diagrams of summer ranges of males represent parts of territories, in the technical sense, we do not know. The great amount of overlapping, and the relatively large sizes of these ranges make such interpretation questionable.

Underlying the interpretations of our summer data is the question: were the males involved unmated? We have assumed that most of them were unmated, although we lack complete proof. There is considerable justification for this assumption: some of the males involved were seen with different females at various times, males consorting with females could seldom be trapped, other workers agree that at least many of the whistling males (which can easily be attracted by decoy females) are unmated (Stoddard, 1931; Thompson and Mattison, 1950; Bennitt, 1951), and

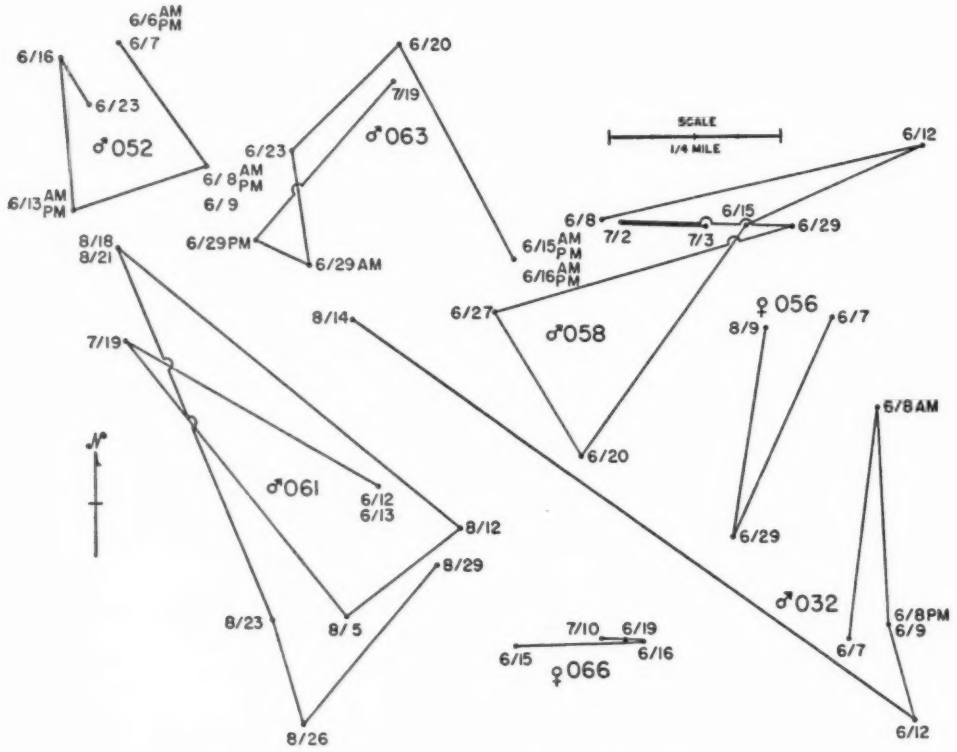


FIG. 1. Summer movements of seven bobwhites.

there was a surplus of adult males on the study area in the fall.

A lack of data for birds known to be mated renders it impossible to do more than surmise that while attending the nests, they were somewhat less mobile than most of the birds for which we had records. Emlen (1939) found that mated pairs of valley quail were decidedly limited in movement during the breeding season, but that nesting failure or loss of a mate induced movement.

In Texas, Lehmann (1946) reported shifting of large numbers of quail during periods of arrested breeding activity between rains. Aging of broods showed the breeding season to be fairly continuous in Missouri, and such shifting did not seem to occur.

Our failure to obtain movement records for 30 of 62 birds trapped at least once during the summer suggested that perhaps these 30 were highly mobile birds which moved beyond the area of study; however, none were found during trips off the area. Moreover, eight of the 30 birds were caught for the first time in August, and may have become sexually inactive before they could be retrapped. Eleven were trapped on the periphery of the study area or just outside, and could probably have avoided recapture by slight movement away from the area. Four were females,

which are taken infrequently in "cock-and-hen" traps. One gave no movement records because it was caught repeatedly at the same trap site.

In view of these facts, it seems reasonable to assume that the birds giving no summer returns were not more mobile than those which did and that the data from retrapped birds, as presented in Table 1, gives a representative picture of summer mobility.

TABLE 1.—DISPERSAL FROM FIRST SUMMER TRAP-SITES

Distance in miles	Number of Individuals	Total Records For These Individuals
0 to 1/4 incl.....	11	33
over 1/4 to 1/2...	17	64
over 1/2 to 3/4...	2	13
over 3/4 to 1.....	1	7
over 1.....	1	2
TOTAL.....	32	119

FALL SHUFFLE

Leopold (1931) described the fall shuffle in quail as a local unoriented movement of coveys, probably not affecting more than a fraction of the total coveys in any locality, and probably seldom exceeding three miles in extent.

That such a shuffle does occur in central Missouri is illustrated by the appearance of a covey of quail, whistling from the roofs of buildings, in downtown Columbia, on October 9, 1950. Our data may reflect the fall shuffle, but are weakened by trapping difficulties in early fall, plus the presence of large numbers of unmarked young birds whose places of origin were not known.

On August 19, 1951, three chicks and a marked adult male were trapped near the north end of the study area. On August 21, the three chicks, with an additional chick, were retrapped at the same site. On September 6, the four chicks were seen off the area, 440 yards north of the trap site. On September 15, marked chicks, almost certainly the same ones, were seen by a farmer 1155 yards north of the trap site. No further records were obtained for them, and it is thought that they probably moved still farther from the area. Their movements may illustrate the fall shuffle.

Three other broods gave four movement records of considerable magnitude: 630, 785, 880, 895 yards. The periods involved in these movements extended from September 6 to December 17. The only other movement of comparable magnitude during fall or winter was one of 674 yards recorded for the lone survivor of a winter covey.

Eighteen birds gave records of movement from summer to winter (Table 2).

TABLE 2.—MOVEMENTS BETWEEN SUMMER AND WINTER

Distance (miles)	Number of Individuals Moving This Distance
0 to 1/4 incl.....	4
over 1/4 to 1/2.....	7
over 1/2 to 3/4.....	2
over 3/4 to 1.....	1
over 1.....	4
TOTAL.....	18

These records indicate somewhat greater mobility in fall than in summer. Only 61 per cent of the birds remained within a half-mile of the last summer trap site; the comparable figure from summer movement records was 88 per cent.

Of the 32 individuals which gave at least one return during the summer, only 11 were trapped on the area during the winter. Since it seems unlikely that

a mortality of two-thirds of the adults would occur during the fall on an unshot area, it is thought that many of the unaccounted-for adults left the area during the fall.

COVEY MOVEMENTS IN FALL AND WINTER

Three hundred and thirty-four individuals were trapped during the fall and winter periods of 1949–50 and 1950–51. One hundred and seventeen bobwhites in nine coveys caught during the fall and winter of 1950–51 gave detailed records of covey movement. Six of the nine coveys were first trapped as broods in the fall and followed the remainder of the winter. The other three were trapped in early winter and followed from that time.

There was ample evidence that these coveys were sedentary: in 43 (86 per cent) of 50 records of movement, they ranged less than a quarter-mile from the first trap site. Five coveys moved more than a quarter-mile from the first fall or winter trap site, but only one moved over a half-mile. This long movement was made in November or early December, and may have been characteristic of the fall shuffle.

Approximate territories in which the nine coveys ranged are shown in the map (Plate 12); the boundaries are rounded-off from trapping and flushing points. In all cases but one, the covey territories were about a quarter or three-eighths of a mile in greatest dimension; the exception (covey number 7) used a territory more than a half-mile long. The average greatest dimension of the territories, as indicated by trapping, was 594 yards, but flushing records extended this average to 654 yards.

Several coveys used parts of their territories for a time, then shifted to other portions. Covey 7 repeatedly shuttled from the north end to the south end of its long territory during the winter (Plate 12). Covey 3 alternated between points A and B (Pl. 12) at almost weekly intervals during much of December, 1950, showing, incidentally, that the bait used in trapping was not effective in holding the birds at one site. Emlen (1939) noted similar use of a local portion of the covey range by valley quail for periods of from a few days to two or three weeks.

Tracking and flushing records showed that the birds rarely used the woods, so the conformity of covey territories to open ridges shown in Plate 12 was real, and not the result of trap locations. Most of the open ridges were occupied by at least one covey.

The territories of several coveys overlapped. Three different coveys were taken at the trap sites marked "X" on Plate 12. These coveys were similar in size and at least in the absence of snow, could easily have been confused had identification not been based on marked birds.

A concentration of quail occurred during the fall of 1951 on an 80-acre tract in the north-central portion of the area. Between September 14 and December 12, 72 birds were trapped on this tract, a density of one bird to 1.1 acres. By the first week in March, only 16 birds remained on the tract, a density of one bird to 5 acres.

Nineteen of the 72 birds are believed to have departed during the fall shuffle as one of them was retrapped later in the winter in a covey more than a quarter-mile south (eighteen gave no

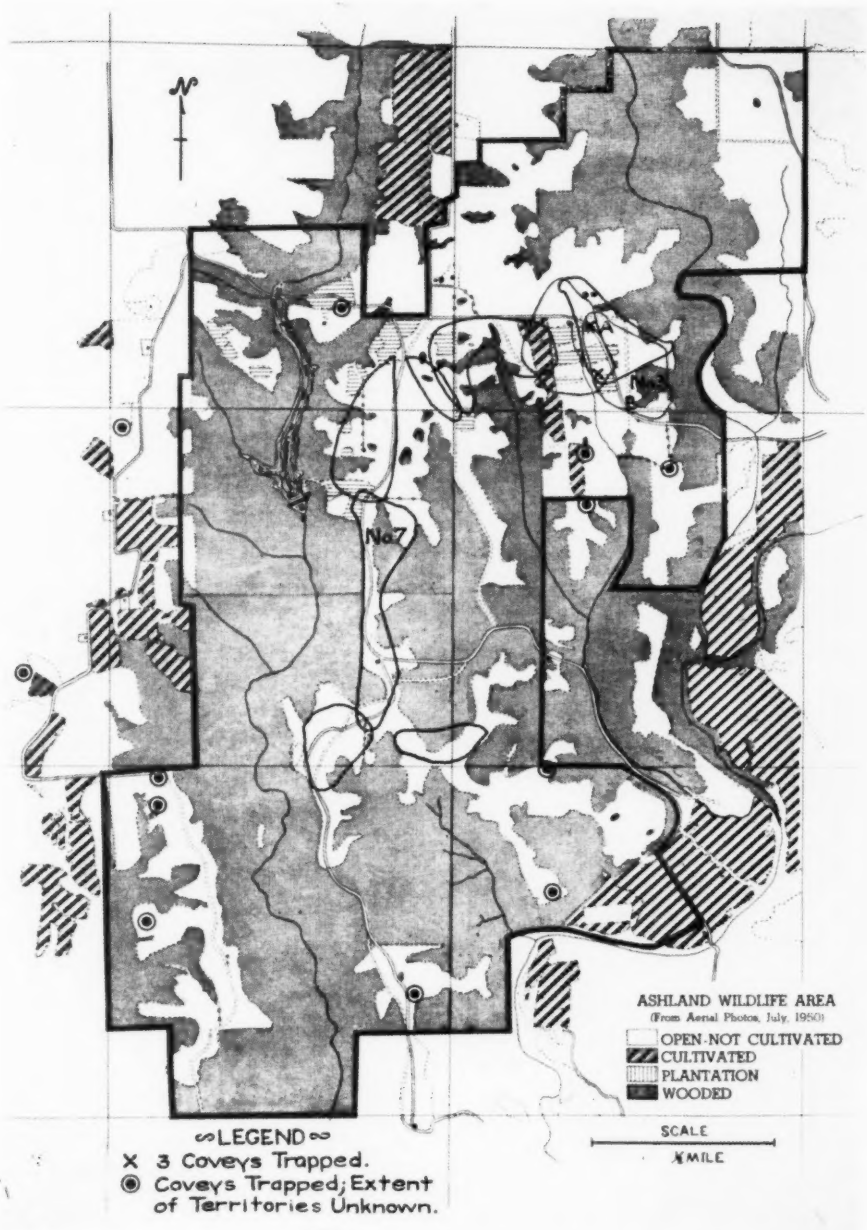


PLATE 12. Approximate covey territories, 1950–51.

returns). The other 53 birds formed five coveys with fall territories inside the 80 acres.

Two of the five coveys later combined and remained on the 80 acres. Two others combined and moved about one quarter-mile north of the tract. The other covey moved about one-eighth-mile southwest. The longest movements recorded for the coveys which departed were made during their departure and show increased mobility in late winter as the result, apparently, of a shrinking habitat.

The general pattern of all covey movement was as follows: a period of adjustment in fall with movements of some coveys exceeding a half-mile; a period of low mobility in mid-winter; and a period of increased mobility in late winter prior to the break-up of coveys. Data on covey composition showed little possibility of ingress or egress during mid-winter.

Winter covey movements were similar to those in Iowa and Wisconsin as described by Errington and Hamerstrom (1936). They stated that cruising radii for coveys living under favorable conditions were short, and that birds could usually by flushed within a quarter-mile of the same place at each visit.

By mid-December, membership of the coveys was stabilized. A few birds dropped out of established coveys, presumably through death, and a few new birds were caught with known coveys, but they may simply have been missed before. The really striking thing was that in only one case during the fall and winter did any one member of a banded covey join another covey. In this case, the bird was the sole survivor of its covey. In other words, there was little or no interchanging of individuals among coveys, despite overlapping of some covey ranges.

After the first of January, remnants of some coveys combined with others. Thus, except for death and combining of remnants, covey membership was constant from December until the spring break-up.

The trapping history of one covey, presented in Table 3, illustrates the statements made above.

TABLE 3.—TRAPPING RECORD FOR COVEY 2

Band numbers	Sept. 14	Oct. 26	Oct. 27	Nov. 28	Dec. 5	Dec. 12	Febr. 17	Febr. 20
063.....	..	..	..	..	x	x	..	..
085.....	x	..	..	x	..	..	..	..
114.....	x	..	..	..	x	..	x*	..
115.....	x	..	x	..	..	..	..	..
116.....	x	..	x	..	..	..	..	..
117.....	x	..	..	x	..	x	..	..
118.....	x	..	..	x	..	..	..	x*
181.....	..	x	..	..	x	..	x*	x*
182.....	..	x	..	x	..	..	x*	x*
230.....	..	..	..	..	x	..	..	..

* Trapped with remnant of covey 5.

SPRING DISPERSAL

Thompson and Mattison (1950) described spring dispersal of bobwhites in Wisconsin as occurring during late March and early April, and involving movements by coveys or individuals. The spring of 1951 was late in Missouri, but definite evidence of spring dispersal was not noted until about mid-April. About that time, one, or possibly two, new coveys appeared on the area, and coveys already there began to break up or leave their winter territories. That spring dispersal in central Missouri may occur earlier was indicated by Murray (1948), who found covey associations loose and birds rapidly leaving

their winter ranges in March, during an unseasonably warm, early spring.

The first "bobwhite" calls were heard on the area on April 15, 1950, and on April 19, 1951; the first whistling male was caught in a trap baited with a decoy female on April 26, 1951. Most quail observed after that date were singles or pairs, but one group of six was seen on May 9, 1951.

Spring dispersal was nearly complete by the last week in May, for trapping after that time produced returns of birds near the sites at which they had been trapped earlier in the spring.

Spring movement records for 1950 and 1951 are combined in Table 4; the

TABLE 4.—SPRING MOVEMENT RECORDS

Distance (miles)	Number of Individuals Moving This Distance
0 to 1/4 incl.	24
over 1/4 to 1/2	17
over 1/2 to 3/4	9
over 3/4 to 1	0
over 1	4
TOTAL	55

table is based mainly on distances moved between the last winter trap-sites and the most distant spring sites in 1951, but also includes some winter-to-summer records for 1950. Forty-one (74 per cent) of the individuals remained within a half-mile of the last winter sites.

The two extreme movements recorded during this study were made (or at least begun) in spring; the birds involved moved two and one-fourth, and two and one-half miles, respectively.

Individuals of the same coveys often dispersed quite differently from the winter territories. One male was trapped during June, July, and August, 1950, never more than a quarter-mile from the nearest winter trap-site. Another male of the same covey was trapped in June and August, one-half- and five-eighths-miles, respectively, from the nearest winter trap-site. A third male of the covey was trapped in July, one and one-fourth miles from the nearest winter trap site.

Of about 75 marked males thought to be present on the area in late winter, 1951, only 21 were trapped or seen in spring, 1951. The 54 birds not giving spring returns may have moved out, but an unknown number may have remained on the area, unresponsive to female decoys and imitated hen calls.

The most striking evidence of spring dispersal was afforded by the ingress of unmarked birds. During the spring of 1951, 28 unmarked and 32 marked birds were caught on the area. We know that a very high proportion of the quail on the 2,240-acre area were marked by late winter (probably over 90 per cent), so that most of the new birds must have moved in. Seven unmarked birds moved in as a covey at least a half-mile, and probably three-quarters of a mile. Evidently, nearly half the birds on the area in the spring wintered outside it.

These data show that spring dispersal accomplishes significant redistribution of quail in Missouri, as suggested by Murray (1948); much importance was attached to spring dispersal in Wisconsin by Buss, Mattison, and Kozlik (1947) and Thompson and Mattison (1950). In Missouri, the spring movements are probably of lesser extent than those in Wisconsin.

ANNUAL MOVEMENTS

Eight birds gave records throughout

an entire year; two gave records from one winter to the next, and six from one summer through the next spring. This small number of birds provided some of the most detailed and valuable movement data of the study. Only 91 birds were trapped early enough in the study so that they could possibly have given year-round returns.

The survival rate on the area was about 15 per cent from the winter of 1949–50 to the winter of 1950–51, for the total populations were approximately equal during both winters, and of 263 birds trapped during the winter of 1950–51, 39 (15 per cent) were adults. Thus, only about 14 birds (91 X .15) could have been expected to give year-round returns, even assuming no permanent egress.

One female apparently remained within a quarter-mile of the banding site, but significantly, we had only two returns for the bird. Four of the eight birds gave all returns within a half-mile of the banding site; the other four ranged up to nearly one and one-half miles from it.

A male (number 008, Fig. 2) banded on January 6, 1950, was retrapped or positively identified ten times during 8 of 14 following months. This bird was very sedentary: it was never caught or seen over three-eighths of a mile from the banding site. On December 31, 1950, almost a full year after banding, it was caught within 50 feet of the banding site.

In Fig. 2 are shown the approximate winter and summer ranges of three birds which gave year-round records. Male 008 exemplifies the extremely sedentary birds, male 063 the intermediate ones, and female 056 the more mobile

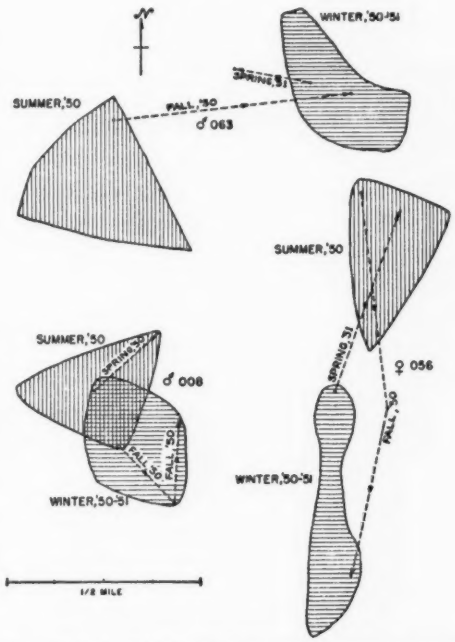


FIG. 2. Approximate winter and summer ranges of three bobwhites (boundaries rounded-off from trapping and flushing points; records for entire coveys used for winter territories).

ones. The winter and summer ranges of male 008 overlapped broadly and the fall and spring movement records (shown by lines) could scarcely be termed dispersal), since they fell within the fall or winter ranges. Male 063 had rather widely separated summer and winter ranges; but there was less spread between the two most distant trap-sites than for female 056.

It is interesting to note that spring and fall dispersal for most birds took place in a northward or southward direction, following the ridges. Relatively few birds crossed the larger valleys on the area.

LIFETIME CRUISING RADII

To deal with lifetime cruising radii, one needs records of maximum move-

ments for the individuals. Summer and winter are periods of relatively low mobility, and thus did not yield suitable records. The best data on maximum movements came from 45 birds giving records of movement during spring and/or fall, the periods of higher mobility. Of these 45 birds, 13 (29 per cent) gave all returns within a quarter-mile of the banding point, while 29 (64 per cent) gave all returns less than a half-mile from it.

From these data, it seems that fewer than one-half of the birds spent their lifetimes within a quarter-mile of the hatching site, but that over 50 per cent probably remained within a half-mile. Some support is given these assumptions by the fact that only one of the eight birds giving year-round records apparently remained within a quarter-mile of the banding point, whereas four apparently remained within a half-mile of it.

DISCUSSION

The findings of this study are in general agreement with those of the early quail mobility studies. The bobwhite in central Missouri is quite sedentary and the majority probably spend their lifetimes within the square mile where hatched. The major point of difference seems to be that in Missouri, about half the birds spend their lifetimes within a half-mile of their birthplaces rather than within a quarter-mile, as reported by Stoddard (1931) for the Southeast and by Leopold (1933).

We could detect no large-scale movements in summer or winter, as described by Lehmann (1946) for Texas bobwhites. This variance can doubtless be explained by differences in ecology of the regions.

MANAGEMENT IMPLICATIONS

Thompson and Mattison (1950) stated that in Wisconsin, even several sections would be risky minimum units of management for quail, and suggested management on a township basis. They reasoned that the observed extensive spring dispersal could take quail from a well-managed farm into poor quail habitat, without compensating ingress to the farm. (Presumably, fall movements could accomplish the same thing.) Consequently, management applied to a single farm would not hold birds through the years unless there was some semblance of quail habitat in the area surrounding the farm.

There are probably few farms in central Missouri which are not bordered by habitable quail range. Nevertheless, it seems unlikely that a 160-acre farm is an adequate unit of management, because apparently fewer than one-third (29 per cent) of the birds giving suitable data in this study remained within a quarter-mile of the banding sites.

Management applied to a single farm might alter the mobility of the quail so as to benefit the farmer somewhat, but management on a larger scale is more desirable both from the standpoint of widespread results which could be obtained, and of benefits to each participating landowner.

If the assumption that about 50 per cent of the quail banded had lifetime cruising radii of less than a half-mile is valid, then one section (square mile) should permanently contain half the quail hatching near its center. Addition of a border strip a half mile wide around

the section should result in permanently retaining nearly all the birds hatched in the center section, and at least half of those hatched in the border strip. Thus, an area of four square miles, two miles on a side, should constitute a safe minimum unit to manage for quail in central Missouri. If mobility is decreased by the management practices, a somewhat smaller area should suffice.

The proposal of a four-section minimum unit is lent credibility by the apparent adequacy in size of the study area itself, since more than half the quail trapped on it in spring, 1951, had wintered there. On the other hand, ingress of nearly half the quail trapped in the spring of 1951 indicates that the area is not much larger than minimum size.

The securing of year-round records for eight of about 14 birds expected to be alive after one year, also adds evidence that fewer than half the birds moved off the area. The study area is 320 acres smaller than the "ideal" four square miles and is irregular in shape, but this irregularity may be compensated in part by the orientation of the ridges.

SUMMARY

1. A study of the mobility of marked wild bobwhite quail was conducted during the period July, 1949 to June, 1951 on the Ashland Wildlife Area, in central Missouri. Four hundred and two individual quail were trapped; 136 of these gave 555 records of movement.

2. Most of the summer data were based on movements of presumably unmated males; some of these birds ranged as far as a half-mile in a single day, but most were less mobile. The ranges of the presumably unmated quail during the entire summer were generally between one-fourth and one-half mile across; diagrams of their ranges indicated that they had geographic orientation and did not merely drift. Eighty-eight per cent of the birds gave all summer returns within a half-mile of the first summer trapping site.

3. There was no evidence of an extensive fall shuffle but fall was a period of generally increased mobility, and the movements of some broods may have been characteristic of the fall shuffle. Sixty-one per cent of the birds giving returns between summer and winter were retrapped within a half-mile of the last summer trap site.

4. Movements of established coveys in fall and winter were not extensive; 43 of 50 records of consecutive movement for nine coveys were less than a quarter-mile in extent. Most covey territories had a greatest dimension of one-quarter to three-eighths mile. Some of the coveys alternately used different parts of their territories.

5. In late fall and early winter, covey membership was fairly constant; after January 1, remnants of coveys began combining and some moved slightly outside of the earlier territories. These moves may have been a response to diminished food, in an area of dense population.

6. Spring dispersal was accomplished both by coveys and by movements of individuals; dispersal started in April and was completed by about June 1. Seventy-four per cent of the individuals giving spring dispersal records were trapped or seen within a half-mile of the last winter trap-site.

7. Somewhat more than half the

quail trapped on the 2,240-acre study area in spring, 1951, had wintered there.

8. Eight of 14 birds expected to be alive after a year gave yearlong records; four of them were not trapped or seen over a half-mile from the banding site.

9. Apparently, about half the quail in this study had lifetime cruising radii of less than a half-mile, for 29 (64 per cent) of 45 birds yielding suitable records gave all returns within a half-mile of the banding site.

10. An area of four square miles was proposed as a minimum unit of management for bobwhites in central Missouri.

LITERATURE CITED

BENNITT, R. 1951. Some aspects of Missouri quail and quail hunting, 1938–1948. Tech. Bull. No. 2, Mo. Cons. Comm. 51 pp.

BUSS, I. O., H. MATTISON, and F. N. KOZLIK. 1947. The bobwhite quail in Dunn County, Wisconsin. Wisc. Cons. Bull. **12**(7): 1–8.

DREW, W. B. 1942. The revegetation of abandoned crop land in the Cedar Creek area, Boone and Callaway counties, Missouri. Univ. of Mo. Ag. Exp. Sta. Bull. 344. 51 pp.

DUCK, L. G. 1943. Seasonal movements of bobwhite quail in northwestern Oklahoma. Jour. Wildl. Mgt., **7**: 365–368.

EMLEN, J. T. 1939. Seasonal movements of a low-density valley quail population. Jour. Wildl. Mgt., **3**: 118–130.

ERRINGTON, P. L. 1933. Mobility of the northern bobwhite as indicated by banding returns. Bird Banding, **4**: 1–8.

———, and F. N. HAMERSTROM, JR. 1936. The northern bobwhite's winter territory. Iowa State Coll. Ag. Exp. Sta. Bull., **201**: 301–443.

LEHMANN, V. W. 1946. Mobility of bobwhite quail in southern Texas. Jour. Wildl. Mgt., **10**: 124–136.

LEOPOLD, ALDO. 1931. Report on a game survey of the north-central states. Sporting Arms and Ammunition Manufacturers' Inst. Madison, Wisc., 299 pp.

———. 1933. Game Management. Charles Scribner's Sons. N. Y., 481 pp.

LINCOLN, F. C. 1947. Manual for bird banders (revised: processed). U. S. Fish and Wildlife Service, Washington D. C., 116 pp.

MURRAY, W. 1948. Wintering bobwhite in Boone County, Missouri. Jour. Wildl. Mgt., **12**: 37–45.

STODDARD, H. L. 1931. The bobwhite quail—its habits, preservation and increase. Charles Scribner's Sons, N. Y., 559 pp.

THOMPSON, D. R., and H. MATTISON. 1950. Quail need food, cover—and space. Wisc. Cons. Bull., **15**(11): 1–4.

WINT, G. B. 1951. Improved method for marking game birds for identification in the field. Bull. Okla. A. and M. Coll., **48**(3): 1–7.

Accepted for publication December 13, 1951.

REVIEWS

The Geography of Hunger. Josué de Castro. Boston, Little, Brown and Company. xiv+337 pp. 1952. $4.50.

"Hunger," as nutritionist de Castro uses the term, is the lack of any of the forty or so constituents needed to maintain health. His book portrays the terrible erosion of hunger that threatens civilization throughout the world. It hacks at the complacency of privileged people concerned solely with maintenance of high living standards in their own regions; and it urges the organization of a world-wide campaign to exterminate hunger, as the only alternative to wars, revolution and the ultimate erosion of civilization.

These are words that we have heard before. What makes this book striking is its crucial point that "overpopulation does not cause starvation in various parts of the world, but that starvation is the cause of overpopulation." This extraordinary claim rests upon two sets of data. The first of these involves experimental work on rats by J. R. Slonaker (Am. J. Physiol. **97**: 322–328) who "found that diets rich in protein . . . increased sterility, retarded the epoch of fertilization in females, and reduced the number of litters and the number of young in each litter." This is actually true, but de Castro conveniently neglects to mention that reproductive efficiency also increased in three of these four particulars when Slonaker placed a group of rats on a medium-protein diet. [In our own field, Morton and Cheatum (J. Wildl. Mgt. **10**: 242–248) have published a striking illustration of the effect of lowering the essential nutrients available to white-tailed deer.]

Not only does de Castro quote Slonaker out of context, but he completely fails to recognize the effects of *overnutrition* that other workers have since investigated. This failure is emphasized by Brody (Proc. Fed. Am. Soc. Exp. Biol. *in press*) who points not only to Carlson and Hoelzel's work on rats (J. Gerontology **6**: 169) but also to the rapidly accumulating medical literature on the subject.

Dr. de Castro's second set of facts is a tabulation of 14 countries, showing an inverse correlation between national birth rates and mean daily consumption of animal protein. While admitting that protein does not exercise an exclusive control on fertility, the author believes that this table "does point up a significant correlation." One could equally well correlate birth rates and numbers of radios . . . and reach similarly absurd conclusions.

The main part of this preposterous volume involves detailed descriptions of the extent and seriousness of hunger on each of the continents. (North America is largely dropped from the New World.) As a nutritionist, Dr. de Castro paints this picture well, but his eyes are not those of an ecologist, and the effects of soil erosion are regarded as something that "could only happen in the distant future." Dr. de Castro further colors his entire account with the sharp prejudices of a political economist. It is not enough to hear that the Malthusian scarecrow was challenged by Marx. Each of the central chapters is a vehement attack on western capitalism. Only Hungary and Poland emerge with honor [agrarian reforms, five-year plans, and the like]. "For compelling reasons," Russia is skipped because "I do not have enough informative data to make an up-to-date analysis in the objective manner with which I have tried to seize the existing reality in the other areas here studied." I had to laugh when I came to that one.

We have here a compelling account of hunger, upon which a half-cooked scientific theory and a prejudiced sense of political economy are put together to formulate a solution. It scarcely deserves notice in this *Journal* except for the depressing circumstance that the author is Chairman of the Executive Council of UN's Food and Agricultural Organization.—J. J. Hickey.

Editor's Note: A communication from Director General Norris E. Dodd of FAO reports that the organization was in no way consulted nor did it in any sense sanction the claims made by the publisher regarding the author's connection with FAO.

"Wildfowl and Waders in the Netherlands" by Dr. I. G. van Maasdyk, Conseil International de la Chasse, The Hague, May 6–9, 1951 (mimeographed paper).

Professional and amateur ornithologists in the Netherlands have been very active in recent years to obtain more data about the status and management of waterfowl and shorebirds in the Netherlands. "Wildfowl and Waders in the Netherlands" gives a review of what has been accomplished.

Several species are still showing a decrease in population. The southern subspecies of the golden plover has disappeared from the Netherlands and North-West Germany as a result of a decrease of nesting, resting and feeding grounds. Golden plovers may still be netted, and approximately 25,000 are caught annually, which are practically all shipped to England. The brent (*Branta bernicla* (L) has apparently been greatly reduced in numbers because of the almost complete disappearance of eel grass (*Zostera marina* L.), probably due to a mould-disease reputed to have come from the United States.

A new Game Law for Holland will prohibit the use of clap-nets. Shot guns are the only arms to be allowed for hunting waterfowl. Spring shooting has been abolished and shooting during frost spells is drastically reduced.

Data are provided on duck-decoys, showing a decline of decoys used. Decoys are not merely destructive, but have a protective function in so far as providing nesting and breeding grounds for waterfowl. The decrease of waterfowl in the Netherlands is not caused primarily by over-shooting or over-catching, but by the decline of suitable ecological conditions.

The United Kingdom is the principal buyer of all exportable Dutch wildfowl. Data presented on the status of breeding waders show that their decline is largely caused by a more intensified practice of land utilization and by increased human populations.

Several lighthouses are still not floodlit, resulting in a high deathrate of migratory birds. A list of waterfowl refuges is presented. In its greatly improved protection system Holland has set a splendid example for other European countries where shooting and capture "en masse" is still going on, day and night.

For information regarding copies of this paper and other Dutch reports please write reviewer or Mr. T. Lebret, Park de Griffioen 17, Middelburg, Holland.—A. DE VOS.

Human Fertility: The Modern Dilemma, by Robert C. Cook, 1951, William Sloan Associates, New York, viii + 380.

In the introduction to this book, Julian Huxley states that "Human population is probably the gravest problem of our time—certainly more serious than war or peace—". This strong assertion is amply documented in a work that is by far the most satisfactory of its kind.

"Human Fertility" is a study of the dynamics of the human population in relation to its world environment and the genetics of the organism. The high competence of Robert C. Cook in this branch of ecology is evident in a treatment which brings recognition and understanding to biological, sociological, and resource influences. The book is written for serious-minded laymen, and the result is particularly satisfying at a time when a bewildered public is being barraged with articles, reports, and even books, that reflect poor scholarship, political bias, and technical bigotry. The present work has no suggestion of these faults, and although the author presents a case which obviously implies misgivings about the future of mankind, he does so with forbearance. No doubt his healthy temperance will in some measure forestall those who greet any questioning of man's racial status with accusations of "doom-calling."

Puerto Rico is taken as a type case representing the world's population bed sores. Previous to acquisition by the United States the island gave tenuous support to a million people, whose high birth rate was balanced by a miserably high death rate. After the Spanish-American War the United States became responsible for Puerto Rico and brought modern medicine—especially yellow fever control—to the island. The result was an "explosion" of population. The death rate declined by a half and the birth rate increased. The 1950 census showed 2.2 million people—slightly more than a third of an acre of overused farm land to provide food, clothing, and shelter for each person in Puerto Rico. Horrible slums, that grow steadily worse, have been the result. And at the present rate of increase the population would double again in 24 years. In slightly more than half a century the U. S. Government

and private philanthropies have expended over a billion dollars on the island.

Productive resources of the island are nowhere near the minimum needed to support present numbers of people. Studies have shown, however, that birth rate is geared to living standard. Birth rate begins to decline after family income reaches $800 per year, and births are equal to deaths after $1500 is reached. Here, as elsewhere, excessive population growth is an economic problem. "What is required . . . is to raise the income of more than 280,000 families at least five hundred dollars per annum. . . ."

A smaller population might achieve a living standard sufficiently high to stabilize numbers, but there is no prospect of achieving this condition while the present excessive birth rate exists. From the story of Puerto Rico, Mr. Cook derives a warning for the American people. "The role of big brother to all the world is a difficult one. The United States has not succeeded with a small island; it is necessary to be sure that future commitments will avoid the mistakes of the past. If human happiness and welfare are the goal, the steps taken must be sure to lead toward it, not away, as they have done in Puerto Rico. There must be no duplication on a global scale of the Puerto Rican debacle." This statement is made in realization of a solemn fact: On this planet more than a billion people face the prospect of this same biological and economic impasse.

The world-wide trend in population is toward rapid increase, with India, Egypt, and Italy notable as "tinder areas." Favorably situated populations have demonstrated the ability to double in 25 years or less, although this growth rate has not been long maintained over any large part of the earth. The checks have sometimes been wars, plague, famine, and a wide assortment of epidemic diseases. In a few countries, social and economic conditions have been achieved which served to stabilize, or even reduce, the population. France, Sweden, and Ireland are notable in this respect. China is a "population powder-keg which could be ignited by bungling good intentions." A high and fluctuating death rate holds the high birth rate in check and keeps millions of people at the limit of sustenance. "If a full-fledged public health program could overnight be initiated in China, the increase . . . could easily total between ten and twenty million per year."

Something similar is occurring in Japan—scene of the most recent U. S. adventuring with a public health program. On this program, and in bringing food to the Japanese, the American people spent one and one-third billion dollars in fiscal year 1949 alone. The wartime death rate of 29 per thousand dropped to 11.4 by 1948. The birth rate increased to 34.8 —more than three times the death rate and 10 points higher than that of the United States. The Occupation turned its back on this problem, preferring to leave the question of what to do with the excess millions to the Japanese. It now appears that the United Nations is about to embark on a similar program in Haiti.

The book has a chapter on "How populations grow", and traces the history of thought in relation to birth control. Mr. Cook reviews the somewhat parallel reception which Darwinism received from the fundamentalists, and implies that further human enlightenment will bring moral sanction to deliberate population regulation.

In a work replete with good writing, the accounts of young Mr. Malthus, Darwin, and Abbot Mendel stand out in vigor and clarity. However, the author's most valuable contribution to his subject is in his sure-footed application of modern genetics to the population problem. He explains the biological mechanism of heredity and discusses the inheritance of intelligence. About four-fifths of human mental ability is due to inheritance and one-fifth to environment. Hence high or low I.Q. tends to be transmitted to the offspring.

In light of this it is significant that average national I.Q. now is barely being maintained. In fact, studies in this country and Great Britain indicate that, because of differential fertility rates in various segments of the population, average I.Q. is declining by 2 or more points per generation. Present trends seem to be selecting desirable characters for high intelligence out of the national "gene pool."

The mechanism through which this "gene erosion" comes about is evident in birth-rate statistics. Births are startlingly low among the well-educated—the 1940 census showed that, as a group, all women who had gone beyond

the third year of high school were failing to replace themselves in the population. Women with no more than four years of education were doubling their numbers with each generation, while college graduates were declining by half. Economically the same condition is evident. The bulk of the new generation are being produced in backward rural areas in families least able to care for them. People of high ability appearing in this group, move to the cities, become educated, and fail to replace themselves. "Economic and educational success works eugenic miracles in reverse in an industrial society. The price for success is a slow, steady, remorseless biological extinction."

The conclusions in this book might well be pondered by our social planners. The economic burden of rearing and educating children weighs most heavily on people who take that responsibility seriously. Such couples limit their families and they are the ones whose offspring society most needs. Sweden and Canada probably have shown a measure of the solution in family and tax allowances for children. Our own security programs are ignoring and penalizing groups that in the national interest should have consideration.

The serious reader cannot fail to leave this book with a feeling that its message is the handwriting on the wall. It shows the way to national strength if its facts could be applied. For once, the biologist can take satisfaction in a work conceived in a sound knowledge of life science and population phenomena.—DURWARD L. ALLEN.

A Study of Pheasants on the 9,000-Acre Prairie Farm, Saginaw County, Michigan, by Charles Shick, Game Division, Michigan Department of Conservation, 134 pp., illustrated, 1952.

In publishing this report, the Michigan Game Division must have weighed with some care the value of the material against disadvantages of the nearly ten years elapsed time since the field work was done. In game-bird population study, such a lapse is significant, and the report suffers somewhat in comparison with current field work. One looks in vain for use of techniques now commonly used, only to realize that they have been developed since the field work in the present publication was completed.

Despite this disadvantage, the bulletin contains so much material that has formed the factual basis for the Michigan hunting policy that its appearance will be welcomed. Many facts here reported have a familiar ring, since they have been cited by other Michigan workers as evidence for more liberal hunting seasons. Most striking of these is that hunting pressure "equivalent to a man hunting 11 hours per day for 22 days on the same 100-acre tract" left an adequate number of cocks for breeding purposes the following spring.

Facts uncovered in the study are discussed under almost all phases of pheasant life history with particular attention given to winter flocks, nesting success, mortality of young, predation, and rate of turnover of population. The hunting season is well covered, including source of hunters, kinds of dogs used, size of guns, and even an estimate of the average number of shots fired per hunter.

The publication is the third of the series of Michigan's Federal Aid reports. It is well illustrated, has 49 tables and 53 figures, is indexed, and has a summary of 6½ pages. The Literature Cited includes 54 titles running as late as 1949. It is to be hoped that this series will be continued, and that more of the wildlife data accumulated by this division will be made available to technical workers.—FRED H. DALE, *Patuxent Research Refuge, Laurel, Maryland.*

BRIEFER ARTICLES

A THROW NET FOR CAPTURING FEMALE WATERFOWL ON THE NEST[1]

Stanley W. Harris

Division of Entomology & Econ. Zoo., Univ. of Minnesota, Univ. Farm, St. Paul 1, Minn.

The importance of renesting data in waterfowl research is becoming more and more evident. Research on renesting requires the capture of the hen on the nest. Several methods of doing this have been devised and they have been discussed by Sowls (Sowls, L. K. 1950. Techniques for waterfowl nesting studies. Trans. N. A. Wildlife Conf., 15: 478–487).

During the summer of 1951, the author carried on waterfowl research in the Potholes Area south of Moses Lake, Grant County, Washington. In the course of the research, a throw net for the capture of females on the nest was developed. The net has a frame constructed of two pieces of one-half inch, thin-walled electric conduit, nine and ten feet long. Each of these pieces was bent into a semicircle. The ends of both pieces were flattened for a distance of six inches and two 5/16 inch holes were drilled three inches apart in each end. The short piece was placed with the flattened ends inside and adjacent to those of the long piece. Machine bolts 5/16 inches in diameter and one inch long were used to bolt the pieces together. The bolts marked "x" (Fig. 1) were provided with lock nuts. This formed a permanent hinge joint. The bolts marked "y" were provided with wing nuts to facilitate their removal. When properly assembled with all four bolts in place, the frame is elliptical in shape, six feet long and five feet wide. Removal of the "y" lock-joint bolts allows the short piece to fold inside the long piece, thus resulting in a fairly compact net which is easy to transport.

To complete the net, this frame was covered with one and three-quarter inch mesh netting which was not removed for folding. The netting should not be stretched tight on the frame but should sag or "belly" at least 18 inches in the middle. The size of the frame, the size of the mesh, and the amount of "belly" can be altered to suit the needs of different cover types.

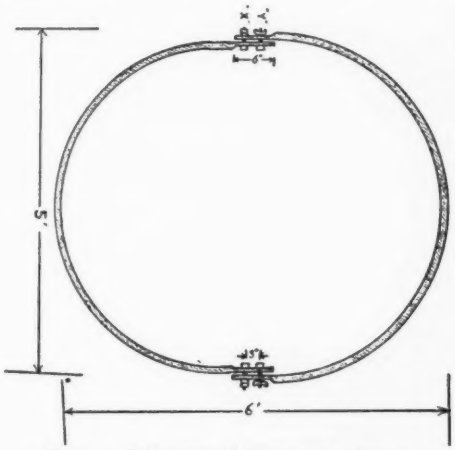


FIG. 1. Diagram of throw net frame.

In the hands of an experienced operator, the net can be thrown with accuracy up to 35 feet. The most effective method of throwing the net is to grasp it with both hands on the small curve of the ellipse and throw it with a pushing motion straight forward.

The net was cast over only four nests which were occupied by females. The nests had been previously marked by placing two stakes, one on each side, three feet from the nest. The net was successful when used in a grassy or scattered short shrubby cover type where it could settle down rapidly. Three of the hens were captured (two in *Juncus balticus* and one in *Rosa woodsii*, short clump) on the first attempt; one mallard, one gadwall, and one blue-winged teal. The fourth nest, a gadwall's, was located in *Scirpus acutus* and although two attempts were made to capture this hen, she escaped from under the net each time before the operator could reach the nest and catch her.

Accepted for publication January 21, 1952.

[1] C. F. Yocom, of the State College of Washington assisted with the research that led to the development of this net in many ways. The Department of Zoology, State College of Washington supplied equipment. C. W. Fairbanks and K. H. Gehrman supplied suggestions that were most helpful.

THE FOX AS A FACTOR IN THE CONTROL OF WEASEL POPULATIONS

Roger M. Latham

Pennsylvania Game Commission, Harrisburg, Pennsylvania

An analysis of bounty records and food habits studies indicates rather conclusively that foxes are effective agents in the reduction and control of weasels in Pennsylvania.

Fox den studies (*Vulpes fulva* and *Urocyon cinereoargenteus*) reveal that many weasels (*Mustela frenata noveboracensis*, *Mustela cicognanii*, and *Mustela rixosa allegheniensis*) are killed by the larger predator even though few are eaten. As many as five or more dead weasels have been observed at one time at fox dens but remained uneaten even after several days. There is good evidence that foxes will kill weasels at every opportunity even though they do not find them particularly palatable. House cats, which also show a decided preference for other food items, are capable of catching several weasels during a year's time, and the fox is certainly a more proficient killer than the cat.

An examination of the Pennsylvania bounty records shows that from 1930 to 1939, when the annual take of foxes averaged 15,000–20,000, the average number of weasels killed per year was 65,500 with a high of 88,578. But as fox numbers irrupted beginning about 1935, the number of weasels presented for bounty became fewer and fewer until in 1944 less than 5,500 were sent to Harrisburg. In the meantime, the fox kill had risen to nearly 50,000 during the 1945–46 and 1946–47 fiscal years. With this tremendous take of foxes and a noticeable reduction in numbers during the next three years, the weasel kill rose to about 20,000 annually. Then with the removal of the red fox bounty in 1949 and the resulting disinterest in fox trapping, the fox population again skyrocketed, and the records for the 1950–51 fiscal year show that the weasel take was less than one-half that of the previous year.

Several explanations are necessary for the reader to understand the position of the population curves in Figure 1. An attempt has been made to allow for discrepancies between the bounty returns and the actual number of weasels and foxes. The population curve for foxes represents the total of both species, although only the gray fox records were constant for the entire period. The red fox bounty was not in effect in the 1929–39 period, in the 1942–45 period, and again in the 1949–51 period. The fox population curve does not follow the gray fox bounty figures because they are not proportional to the actual population in many cases. For instance, until the advent of the famous "dirt-hole set," few trappers were capable of taking these animals in numbers. The irruption of foxes preceded this new trapping technique, and just when the fox kill was beginning to increase more nearly proportional to the rising population, World War II disrupted this trend. However, fox numbers continued to rise during the war period as shown by the curve.

The weasel curve does not follow the precipitous dip from 1937 to 1938 because, here again, the bounty figures are misleading. The reduction of the bounty fee from $1 to $.50 in 1937 exaggerated the rate of decline.

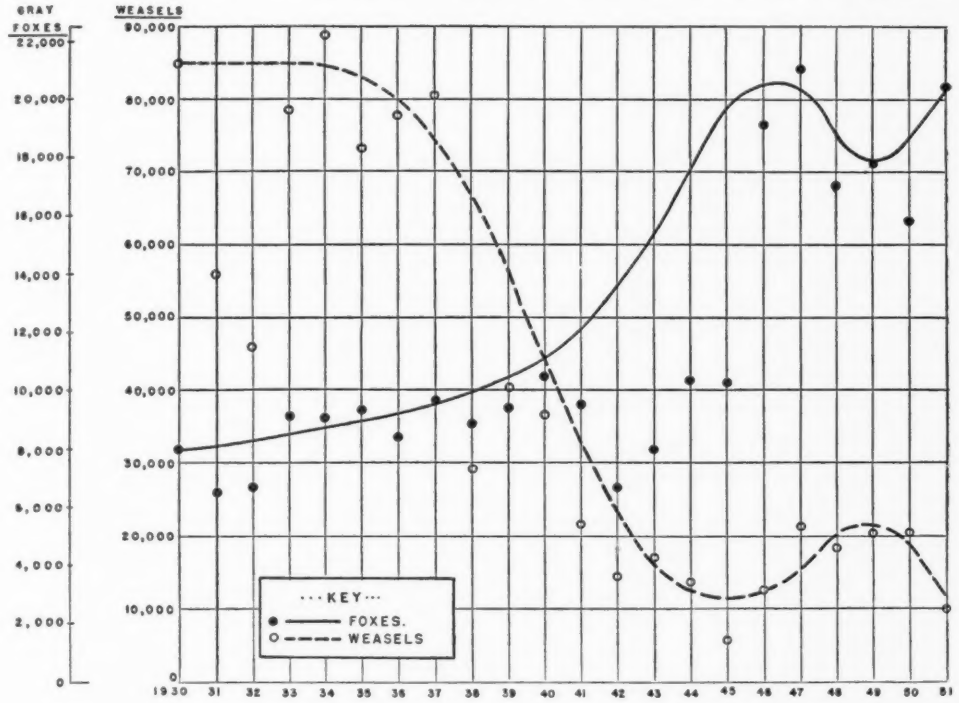
Further evidence to indicate this interspecific strife is revealed by an analysis of county bounty figures. A relationship is shown in Table 1 between the number of weasels and the numbers of foxes bountied in the various counties. The four fiscal years between 1945–46 and 1948–49 were used for this analysis because they represent the most recent period during which a bounty was paid upon both red and gray foxes simultaneously.

TABLE 1.—RELATIONSHIP BETWEEN THE KILL OF FOXES AND WEASELS BY COUNTIES FOR THE FOUR-YEAR PERIOD, 1946–49.

Counties with annual weasel kill between:	Weasel : fox ratio
1–99	1 : 9.33
100–199	1 : 4.06
200–299	1 : 2.75
300–399	1 : 1.86
400–499	1 : 1.24
500 or more	1 : 0.99

As the numbers of weasels bountied per county increased, the ratio between weasels and foxes approached unity. There appeared to be no correlation between the county

FIGURE 1 — FOX-WEASEL RELATIONSHIP BASED ON BOUNTY RETURNS



weasel-fox ratios and the amount of agricultural or forested land in the various counties.

As would be expected, an examination of individual county bounty records reveals a trend similar to that for the entire state. Certain of the counties in the northwestern portion of Pennsylvania, *cf.* Mercer and Crawford, supported an almost negligible number of foxes before 1930. The number of weasels bountied annually decreased markedly as foxes moved into these counties and gradually reached abundance. In Mercer County during the period from 1930 to 1936 from 1 to 11 foxes were presented annually for bounty. An average of 1,674 weasels were bountied each year during this same period. The gradual increase of foxes from 1937 to 1944 to a yearly average of 57 submitted for bounty appeared to reduce the average weasel kill to 636. An average kill of 189 foxes during the 1945–49 period was paralleled by a further reduction in the weasel take to 427 per year.

From the evidence presented, it appears logical to assume that where foxes are numerous in Pennsylvania they are capable of reducing and controlling the resident weasel population.

Accepted for publication December 14, 1951.

RECENT PUBLICATIONS

Fish and Wildlife Conservation in River Basin Development. Office of River Basin Studies, Fish and Wildlife Service, Washington, D. C. 68 pp. illus. June 1952. (Processed)

Guide to the Mammals of Colorado. By Hugo G. Rodeck. University of Colorado Museum, Boulder, Colorado, Leaflet No. 10. 72 pp. illus. September 1952. $.75.

Mammals of Kansas. By E. Lendell Cockrum. University of Kansas Publications, Museum of Natural History, Lawrence, Kansas. Vol. 7 No. 1: pp. 1-303. August 25, 1952.

Mammals of Utah, Taxonomy and Distribution. By Stephen D. Durrant. University of Kansas Publications, Museum of Natural History, Lawrence, Kansas. Vol. 6: pp. 1-549. August 10, 1952.

Yale Conservation Studies. Yale Conservation Club, New Haven, Conn. Vol. 1, No. 1, 1952.

A General Summary of the Food of Missouri Predatory and Game Animals. By Leroy J. Korschgen. Missouri Conservation Commission, Jefferson City, Missouri. Fed. Aid to Wildlife Restoration Program, Food Habits Study, Surveys and Investigations Projects, Missouri 13-R-4 (1950), Pittman-Robertson Program. 61 pp. Processed. July 1952.

Tularemia, Weather, and Rabbit Populations. By Ralph E. Yeatter and David H. Thompson. Bull. of the Ill. Nat. Hist. Survey, Vol. 25, Article 6: pp. 351-382. illus. June 1952.

NEWS AND NOTES

During the past year the Editor has been asked on several occasions for an explanation of the hieroglyphics on the cover of the JOURNAL OF WILDLIFE MANAGEMENT. The explanation did appear in the first issue of the Journal published, but since many present members may not have access to that, it seems worthwhile to quote in full the three paragraphs prepared at that time by W. L. McAtee, our first Editor:

"The field covered by wildlife management is extensive, including as it does animals and their environment. When an attempt was made to design a cut for the cover of the new Journal, it was found impossible to include in a simple, well-composed design representations of all the important elements involved in the wildlife field. Such a representation was therefore abandoned and a brief study was made of symbols and pictorial writing.

"As pre-Columbian Americans thought of the various kinds of animals and plants as entirely distinct beings, without connection in functions or structure, their pictorial forms of representation did not, seemingly, include comprehensive symbols for the larger groups, comparable to our classes or phyla. Next, Egyptian hieroglyphics were considered by Victor H. Cahalane, our Secretary, as a possibility. J. E. Lodge, Curator of the Freer Gallery of Art in Washington very kindly pointed out several appropriate words and furnished photographs of them. They were then reproduced in a pen and ink drawing by Walter A. Weber, artist of the National Park Service. The editor wishes to acknowledge with appreciation the gift of time and thought to this matter by Messrs. Cahalane, Lodge, and Weber.

"The literal translation of the words, from top to bottom is as follows: beasts, birds, fishes, flowering plants."

NOMINATIONS FOR SOCIETY OFFICERS

1953 - 1954

Herewith is the slate of nominees prepared by the Nominations Committee to be voted on for the period of office in 1953-1954.

President
C. H. D. Clarke
Justin W. Leonard

Vice-President
W. C. Glazener
Harlow B. Mills

Secretary *
Kenneth D. Carlander
Allen W. Stokes

Respectfully submitted,
The Nominating Committee

Robert C. Ball
Daniel W. Lay
H. G. Lumsden
Edward C. Raney
Lee E. Yeager, *Chairman*

* Since the above report was submitted, the Council has appointed Dr. George A. Petrides Executive Secretary for 1953-54, which supersedes this nomination.

INDEX FOR VOLUME 16

Aerial photography, for land-use and cover mapping, 227–320
Age determination
  coot, American, 191
  quail, bobwhite, 109
Aldous, Shaler E. Deer browse clipping study in the Lake States region, 401–409
Aldrich, John W. The source of migrant mourning doves in southern Florida, 447–456
Aldrin, spray, effects on birds, 326, 492
Allen, A. A. Obituary of J. Southgate Hoyt, 214
Allen, Durward L. Book review, 512–514
Antelope, food habits, 387
Arthur, George C., see Shanks, Charles E., 138
Ashbrook, Frank G. Obituary of Herbert L. Dozier, 379–380
Asparagus, as pheasant food, 50
Atkeson, Thomas Z., and Lawrence S. Givens. Upland farming as a method of supplementing the natural waterfowl food supply in the southeast, 442–446
Atkeson, Thomas Z., and David C. Hulse. Crippling as a factor in gray squirrel hunting, 230–232
  also, see Givens, Lawrence S., 107

Bailey, R. Wayne, see Uhlig, Hans G., 24
Baldini, James T., R. E. Roberts, and C. M. Kirkpatrick. Studies of the reproductive cycle of the bobwhite quail, 91–93
  also, see Kirkpatrick, Charles M., 54
Ball, Robert C. Farm pond management in Michigan, 266–269
Barber, Harold L. Mobility of the white bass, *Lepibema chrysops* (Rafinesque), 115
Barnickol, Paul G., and Robert S. Campbell. Summary of selected pond studies in Missouri, 270–274
Baskett, Thomas S., see Murphy, Dean A., 498
Beaver, ponds, 69
  rabies in, 226
Beck, John R. A suggested food rank index, 398–399
Benson, D. A. Treatment of sick moose with cobaltous chloride, 110–111
Bennett, George W. Pond management in Illinois, 249–253
Big game ranges, infiltration on, 224
Birds, effects of chlordane and aldrin on, 326, 492
Bishop, Louis B. (Obituary), 94
Boldt, Wilbur, and George O. Hendrickson. Mourning dove production in North Dakota shelterbelts, 1950, 187–191
Bonnot, Paul (Obituary), 214
Brakhage, George K., and Frank W. Sampson. Rabies in beaver, 226
Brown, C. J. D., and Nels A. Thoreson. Ranch fish ponds in Montana, 275–278
Burcalow, Donald W., see Gunvalson, V. E., 121
  also, see Stenlund, Milton H., 58
Bumblefoot, in pheasants, 399

Campbell, Robert S., see Barnickol, Paul G., 270
Carlander, Kenneth D. Farm fish pond research in Iowa, 258–261
Cheatum, E. L. Book review, 95
Chlordane bait, effects on birds, 326
Clark, Minor. Kentucky's farm fish pond program, 262–266
Clemens, Howard P. Cove selection and use of gill nets in fish population surveys in large impoundments, 393–396
Cobaltous chloride, treatment of moose with, 110
Cole, La Mont C. Book review, 98
Compton, Lawrence V. Farm and ranch ponds, 238–242
Conaway, Clinton. The age at sexual maturity in male elk (*Cervus canadensis*), 313–315
Control
  mole, prairie, 419
  weasel, 516
Coot, American, sex and age determination, 191
Corrections, 94, 106
Cover mapping, aerial photography in, 227, 320
Cowan, I. McT., and James Hatter. A trap and technique for the capture of diving waterfowl, 438–441
  Book reviews, 96, 102
Croker, Richard S. Obituary of Paul Bonnot, 214–215

Dale, Fred H. Sex ratios in pheasant research and management, 156–163
  Book review, 514

Deer
browse clipping study, 401
death by bearded grains, 113
mule
food habits in Utah, 148
forages, 309
mortality, 289
population fluctuations, 121
repellents, effect on foliage, 390
white-tailed, bag checks, 58
de Vos, Antoon, and Stanley E. Guenther. Preliminary live-trapping studies of marten, 207–214
Book review, 511–512
Doves
mourning, autopsying, 108
production, 187
source in southern Florida, 447
Trichomoniasis in, 164
trapping and marking of, 87
Dozier, Herbert L. (Obituary), 379
Dusi, Julian L. The food habits of several populations of cottontail rabbits in Ohio, 180–186

Eagle, golden, food habits of, 457
Edminster, Frank C. Book review, 215–216
Elder, William H. Failure of placental scars to reveal breeding history in mink, 110
Elk, age at sexual maturity, 313
Emlen, John T., Jr., see Young, Howard, 169
Eng, Robert L. A two-summer study of the effects on bird populations of chlordane bait and aldrin spray as used for grasshopper control, 326–337
Erickson, Arnold B. A case of bumblefoot in the ring-necked pheasant, 399–400
also, see Gunvalson, V. E., 121
Evenden, Fred G., Jr. Waterfowl sex ratios observed in the western United States, 391–393

Farm ponds, management problems in several states and Canada (12 papers), 233–288
muskrats in, 138

Fish
bass, white, 115
marine, mortality, 63
population surveys, 393
weight changes after death, 131
whitefish, 39

Fox
as factor in weasel control, 516
gray, population, 198
Food habits
antelope, 387
deer, mule, 148
eagle, golden, 457
food rank index, 398
porpoise, 396
rabbits, cottontail, 180
seal, fur, 396
sea-lion, 396
waterfowl, migratory, 228
Fur productivity, 79

Gashwiler, Jay S., see Robinette, W. L., 289
Geese, Canada, techniques for increasing nesting, 425
Gilbert, Neil. Letter to the Editor, 232
Givens, Lawrence S., and Thomas Z. Atkeson. Use of Italian rye grass as a means of attracting waterfowl, 107–108
also, see Atkeson, Thomas Z., 442
Glass, Bryan P. Factors affecting the survival of the plains muskrat, *Ondatra zibethica cinnamomina*, in Oklahoma, 484–491
Goose, Hawaiian, 1
Graham, Edward H. Book review, 97
Grizzell, Roy A., Jr. Selectivity of mirror traps, 114–115
Guenther, Stanley E., see de Vos, Antoon, 207
Gullion, Gordon. Sex and age determination in the American coot, 191–197
Gunshot, effect on bobwhites, 54
Gunter, G. The import of catastrophic mortalities for marine fisheries along the Texas coast, 63–69
Gunvalson, V. E., A. B. Erickson, and D. W. Burcalow. Hunting season statistics as an index to range conditions and deer population fluctuations in Minnesota, 121–131

Hamilton, W. J., Jr. Book review, 382–383
Hanson, William R. Effects of some herbicides and insecticides on biota of North Dakota marshes, 299–308
Harris, Stanley W. A throw net for capturing female waterfowl on the nest, 515
Hatter, James, see Cowan, I. Mc.T., 438
Haugen, Arnold O. Trichomoniasis in Alabama mourning doves, 164–169
Hendrickson, George O., see Boldt, Wilbur, 187

Henning, Willard L. Studies in control of the prairie mole, *Scalopus aquaticus machrinus* (Rafinesque), 419–424
Herbicides, effect on biota of marshes, 299
Hewitt, O. H. Book reviews, 216–217
Hickey, Joseph J. Monthly distributions of mallard hunting mortality, 32–38
Book review, 511
Hjersman, Henry A., see Howard, Walter E., 390
Honess, Ralph F., and Kenneth Winter. A cultural media kit for field use, 225
also, see Winter, Kenneth B., 111, 113
Howard, Walter E., and Henry A. Hjersman. Deer repellent sprays not harmful to foliage on two-year-old trees, 390–391
Hoyt, J. Southgate (Obituary), 214
Hunting statistics, 121

Insecticides, effect on biota of marshes, 299

Julander, Odell, see Robinette, W. Leslie, 289

Kalmbach, E. R. Book review, 381–382
Kenyon, Karl W., see Wilke, Ford, 396
Kirkpatrick, Charles M., Donald E. Stullken, and James T. Baldini. Effect of simulated gunshot injuries on reproduction of game farm bobwhites, 54–58
also, see Baldini, James T., 91
Kossack, C. W. A method for autopsying a mourning dove kill, 108
Kozicky, Edward L. Variations in two spring indices of male ring-necked pheasant populations, 429–437
Kozicky, Edward L., and Henry G. Weston, Jr. A marking technique for ring-necked pheasants, 223
Krumholz, Louis A. Management of Indiana ponds for fishing, 254–257

Larimore, R. Weldon. Weight changes in fish after death, 131–138
Latham, Roger M. The fox as a factor in the control of weasel populations, 516–517
Law enforcement, technique for aiding, 111
Lawrence, William H. Evidence of the age of beaver ponds, 69–79
Lay, Daniel W. Book review, 102
Leedy, D. L. Obituary of B. Bishop, 94
Levi, Herbert W. Book review, 220–221
Linduska, J. P. Book review, 100
Llewellyn, Leonard M., see Uhler, Francis M., 79

Mallard, hunting mortality of, 32
Marshes, effect of insecticides on biota of, 299
Marten, live-trapping, 207
Mason, Ellis. Food habits and measurements of Hart Mountain antelope, 387–389
Mast index, 338
McHugh, J. L. Fur seals preying on black-footed albatross, 226
Meehean, O. Lloyd. Problems of farm fish pond management, 233–238
Mendall, Howard L. Book review, 220
Mice, trap response in, 169
Miller, Richard B. The relative strengths of whitefish year-classes as affected by egg plantings and weather, 39–50
Mink, breeding history, 110
Mohler, Levi. Fall and winter habits of prairie chickens in southwest Nebraska, 9–23
Mole, prairie, control, 419
Moose, treatment with cobaltous chloride, 110
Morse, Marius A., see Stenlund, Milton H., 58
Mortality,
deer, mule, 289
fish, marine, 63
mallard, 32
Muenscher, W. C. Book review, 103
Murphy, Dean A., and Thomas S. Baskett. Bobwhite mobility in central Missouri, 498–510
Muskrat
movements, 138
survival, 484

Neess, John, see Young, Howard, 169
Nelson, Bernard A., see Stenlund, Milton H., 58
Nene, 1
Nestler, Ralph B., see Petrides, George A., 109
Notes and News, 232, 400, 518–519

Obituaries
Bishop, Louis B., 94
Bonnot, Paul, 214
Dozier, Herbert L., 379
Hoyt, J. Southgate, 214

Peterson, Randolph L. Book review, 218–219
Petrides, George A., and Ralph B. Nestler. Further notes on age determination in juvenile bobwhite quail, 109–110

Pheasant, breeding population, 409
bumblefoot in, 399
food of, 50
marking technique for, 223
populations, 429
sex ratios, 156
Populations, pheasant, 409, 429
weasel, 516
muskrats, 138
Porpoise, food habits, 396
Post, George. The effects of aldrin on birds, 492–497
Prairie chickens, fall and winter habits of, 9
Precipitation, relation of fox population to, 198

Quail,
(bobwhite)
age determination, 109
aids for studying, 316
effect of gunshot on, 54
mobility, 498
reproductive cycle, 91
California, in New Zealand, 460
Quimby, Don C. Book review, 217–218

Rabbits, cottontail, food habits, 180
Rabies, in beaver, 226
Raney, Edward C. Book reviews, 103, 104, 383
Range conditions, 121
in relation to deer mortality, 289
Rawson, D. S., and R. A. Ruttan. Pond fish studies in Saskatchewan, 283–288
Recent publications, 105–106; 222; 386; 518
Reeves, Maurice C. Mechanical aids useful in studying bobwhite quail, 316–319
Reviews, 95–105; 215–221; 380–386; 511–514
Richmond, Neil D. Fluctuations in gray fox population in Pennsylvania and their relationship to precipitation, 198–206
Roberts, R. E., see Baldini, James T., 91
Robinette, W. Leslie, *et al.* Winter mortality of mule deer in Utah in relation to range condition, 289–299
Ruttan, R. A., see Rawson, D. S., 283

Saila, Saul B. Some results of farm pond management studies in New York, 279–282
Salinger, Herbert E. A pheasant breeding population study on irrigated lands in southwest Idaho, 409–418
Schorger, A. W. Book review, 99
Schultz, Vincent. An application of aerial photography to land-use and cover mapping, 227–228
Sea-lion, food habits, 396
Seal, fur, food habits, 396
prey on albatross, 226
Sex determination, American coot, 191
Sex ratios
coot, American, 195
pheasants, 156
waterfowl, 391
Shanks, Charles E., and George C. Arthur. Muskrat movements and population dynamics in Missouri farm ponds and streams, 138–148
Smith, Arthur D. Digestibility of some native forages for mule deer, 309–312
Smith, J. Donald. The Hawaiian goose (Nene) restoration program, 1–9
Smith, Justin G. Food habits of mule deer in Utah, 148–155
also, see Robinette, W. L., 289
Squirrel, gray, crippling, 230
Stenlund, Milton, *et al.* White-tailed deer bag checks, Gegoka Management Unit, Superior National Forest, 58–63
Storer, Tracy I. Book review, 384–385
Stullken, Donald E., see Kirkpatrick, Charles M., 54
Swank, Wendell G. Trapping and marking of adult nesting doves, 87–90
Swanson, Carl V. Asparagus as emergency pheasant food, 50–53
Swanson, Gustav A. Book reviews, 105, 383–384
Review, 101
Swift, Lloyd W. Book review, 380–381
Swingle, H. S. Farm pond investigations in Alabama, 243–249

Techniques
aerial photography, 227, 320
bobwhite quail study, 316
doves, trapping & marking, 87
evaluation of mast index, 338
field cultural media kit, 225
fish population surveys, 393
increasing goose nesting, 425
marking, pheasants, 223
measuring age of beaver ponds, 69
mirror traps, 114
mourning dove autopsying, 108
pheasants, marking, 223
transmission spectra and crystallography in

law enforcement, 111
use of Italian rye grass in attracting waterfowl, 107
waterfowl capture, 438, 515
Thoreson, Nels A., see Brown, C. J. D., 275
Tigerman, Merle H. Observations of infiltration rates and sediment production on big game ranges, 224–225
Trapping, marten, 207
mice, 169
mirror traps, 114
quail, 316
Trichomoniasis, in doves, 164
Turkey, wild, 24

Uhler, Francis M., and Leonard M. Llewellyn. Fur productivity of submarginal farmland, 79–86
Uhlig, Hans G., and R. Wayne Bailey. Factors influencing the distribution and abundance of the wild turkey in West Virginia, 24–32
Uhlig, Hans G., and H. Lee Wilson. A method of evaluating an annual mast index, 338–343
Upland farming for waterfowl food supply, 442

Waterfowl
attracting, 107
capture, 438–515
food supply, 442
migratory, food of, 228
sex ratios, 391
Weasel control, 516
Westerskov, Kaj. Book review, 101
Whitefish, year classes, 39
Wildlife Society, The
Constitution and By-Laws, 116–120
Reports of officers and committees, 344–378
Wilke, Ford, and Karl W. Kenyon. Notes on the food of fur seal, sea-lion, and harbor porpoise, 396–397
Williams, Gordon R. The California quail in New Zealand, 460–483
Wilson, H. Lee, and Edward V. Berard. The use of aerial photographs and ecological principles in cover type mapping, 320–326
also, see Uhlig, Hans G., 338
Wingard, Robert G. Foods of some migratory waterfowl in Pennsylvania, 228–230
Winter, Kenneth B., and Ralph F. Honess. Bearded grains cause death of deer, 113–114
The use of transmission spectra and crystallography of hemoglobin in law enforcement, 111–113
Woodgerd, Wesley. Food habits of the golden eagle, 457–459

Yocom, Charles F. Techniques used to increase nesting of Canada geese, 425–428
Young, Howard, John Neess, and John T. Emlen, Jr. Heterogeneity of trap response in a population of house mice, 169–180

Zorichak, John L., see Stenlund, Milton H., 58

SUGGESTIONS ON MANUSCRIPTS AND ILLUSTRATIONS

The Journal publishes sound original articles, discussions, and reviews on wildlife research, management, and administration. The author (or one of joint authors) must be a member of the Society in good standing; exceptions need special approval by the Editor and President (ruling of Council, Feb. 16, 1941).

In general, papers will be published in order of receipt of copy in final form. Any requiring major changes will be returned promptly. Suitability is judged by the content of significant new material, concisely stated, with scientific accuracy and clarity of expression. If necessary, enlist the aid of a local editor or instructor in English in matters of style, grammar, and punctuation. The University of Chicago "Manual of Style" (1937), S. F. Trelease and E. S. Yule "Preparation of Scientific and Technical Papers" (1936, Baltimore, Williams & Wilkins Co.), and similar manuals are helpful aids. Even most experienced authors find difficulty in detecting all errors in their own papers. Have your associates read and criticize your manuscript before final typing.

Copy should be typewritten on substantial white paper (8½″ x 11″, 8″ x 10½″), *entirely double-spaced*, with margins of about 1½ inches and pages numbered at upper right. Do not fold manuscript. Neatness assists both editor and printer in preparing manuscript for publication. Underscore only scientific names. Author's complete address (to which proof is to be sent) should appear at upper left corner of first page. Carbon copies, copies on onion skin, and single spacing are not acceptable. The author should retain a carbon copy for reference as manuscripts (and illustrations) are not insured.

The title should be concise and descriptive, preferably not more than 10 words, as an aid in bibliography. In general, avoid footnotes by incorporating such material in the text. Where necessary number them consecutively throughout the article. Acknowledgments are best given in a brief footnote to the title. Headings should be few, and of only two or three classes. Articles of more than 5 or 6 typed pages should have a concise summary, understandable without reference to the text.

Tables should be few, of simple form with a minimum of columns and a concise heading, and prepared in keeping with the size of the Journal column or page; type each table (or 2 small ones) on a separate sheet. Duplication of data in text, tables, and charts is rarely necessary and usually will result in return of a manuscript for elimination. Long tables of food materials or plants are rarely of general interest; short lists, with pertinent comments, are preferable. Percentages should not imply greater accuracy than the original data; 0.1 per cent means "parts per thousand", a measure rarely attained in wildlife research; indicate items of 0.1 per cent or less as "traces" (tr.). State sex ratios as *males:* 100 *females*, not as percentages.

References to literature, if five or less, may be inserted in parentheses at the proper places in the text. For a list of literature cited arrange the entries in alphabetical sequence by author's surnames and dates; each should include the full title, the name of the journal or place and publisher of a book, and the volume and paging. See recent issues of the Journal for style. All references should be checked carefully against original sources.

Copy for illustrations should be suitable for photographic reproduction without retouching, redrawing, or setting type at the margins. Line drawings should be in India ink on white drawing paper or bristol board and planned for column (2⅜″) or page width (5″) when reduced. Copy should not exceed 8½″ x 11″. Make letters and numbers large enough to be at least 1/16″ tall when reduced. For graphs use white paper, tracing cloth, or blue cross-ruled paper; orange or green cross-rulings do not reproduce well. A minimum of photographs for illustrations as plates will be accepted because of the high cost of reproduction. Submit prints of good contrast on glossy paper not exceeding 5″ x 7″. Identify each drawing or photograph on the back lightly in pencil ("Jones, muskrats, fig. 4"); do not paste on cards or sheets. Type legends as paragraphs, double-spaced, all in sequence, on a separate sheet. Put all tables, illustrations, and legends at the end of the article.

The printer sends proof and manuscript to the author. Proof should be read, compared and corrected, signed by the author, and sent promptly, with the manuscript, to the Editor, including also an abstract on the blue form supplied. The galley proof stage is not the proper time for editorial changes by the author. Changes or additions to the proof often require costly resetting of type which will be charged to the author. Any major alteration needed is preferable at the end of a paragraph or as a new paragraph.

A white form, with the proof, provides for ordering reprints. Correspondence about reprints should be sent to the Printer. Sample costs for reprints are as follows: 4 pages, 100 copies, $3.50; additional 100, $2.00; 8 pages, $6.00, $3.20; 16 pages, $10.15, $4.80; 24 pages, $15.75, $7.55. Inserts, 1 page $4.75, $2.50. Covers (Journal stock), $5.60, $2.80. Postage will be charged at cost.

CAYUGA PRESS, INC., ITHACA, NEW YORK

THE WILDLIFE SOCIETY

The Wildlife Society was founded on February 28, 1937. Its principal objectives are: (a) Establishment of professional solidarity and maintenance of the highest possible professional standards; (b) development of all types of wildlife management along sound biological lines; (c) publications to effect these ends; and (d) protection of the interests of its members. These purposes are served by annual meetings, regional meetings, correspondence between members, and publication of the quarterly Journal of Wildlife Management and of the quarterly Wildlife Newsletter.

Any member may become a *Life Member* by paying the sum of $100.00 at one time or in four equal annual installments into the Permanent Trust Fund. Life Members shall be exempt from payment of annual dues.

Membership is open to any interested person who is sponsored by two Members; dues are $5.00 annually of which $4.00 is a subscription to The Journal of Wildlife Management. *Honorary Members* are persons recognized for distinguished service or outstanding achievement in wildlife management. All classes of members receive The Journal and Newsletter. Applications for membership should be made to the Secretary.

The Society is governed by the elected Council, composed of the four general Officers and seven Regional Representatives, one from each of the six regions of the United States and one from Canada.

Officers

President: Daniel L. Leedy, U. S. Fish and Wildlife Service, Washington 25, D. C.
Vice-President: Paul D. Dalke, Cooperative Wildlife Research Unit, University of Idaho, Moscow, Idaho.
Secretary: W. C. Glazener, Game and Fish Commission, Austin, Texas.
Treasurer: E. L. Cheatum, Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana.

Regional Representatives

Durward L. Allen (Region 1, northeast), U. S. Fish and Wildlife Service, Washington 25, D. C.
Arnold O. Haugen (Region 2, southeast), Wildlife Bldg., Auburn, Alabama.
Thomas R. Evans (Region 3, north central), 195 S. Cleveland Ave., St. Paul, Minn.
Levi L. Mohler (Region 4, northern Great Plains), 1000 S. 35th St., Lincoln, Nebr.
W. B. Davis (Region 5, southwest), Texas A. & M. College, College Station, Texas.
A. Starker Leopold (Region 6, far west), Museum of Vertebrate Zoology, Univ. of Calif., Berkeley 4, Calif.
C. David Fowle (Region 7, Canada), Route 2, Maple, Ontario, Canada.

Trustees

Herford Naylor Elliott, 1953; C. R. Gutermuth, 1954; Charles B. Belt, 1955.

Editorial Staff

Gustav A. Swanson, Editor, *Journal of Wildlife Management;* Oliver H. Hewitt and Kenneth D. Carlander, Associate Editors; H. S. Mosby, Editor, *Wildlife Society News.*

Committees

Archives: P. F. English, Chairman; Roger M. Latham; Ward M. Sharp.
Awards, Fisheries Publication: Robert S. Campbell, Chairman; George W. Bennett; Paul F. Eschmeyer; Carl L. Hubbs; Karl F. Lagler.
Awards, Leopold Medal: Robert A. McCabe, Chairman; Edward H. Graham; O. J. Murie; Lloyd W. Swift; Edward L. Wickliff.
Awards, Terrestrial Publication: Ian M. Cowan, Chairman; Helmut K. Buechner; Walter F. Crissey; Ben Glading; Victor E. F. Solman.
Constitutional Revision: W. B. Davis, Chairman; Shaler E. Aldous; Warren W. Chase; C. R. Gutermuth; E. R. Kalmbach.
Employment: Lansing A. Parker, Chairman; Merle A. Gee; Laurence E. Riordan; William F. Sigler; Harold V. Terrill.
Finances: E. L. Cheatum, Chairman; C. B. Belt; Walter A. Gresh.
Job Standards: Norman G. Wilder, Chairman; I. T. Bode; Seth Gordon; Harry D. Ruhl; Stillman Wright.
Membership: George A. Petrides, Chairman; C. H. D. Clarke; William R. Eschmeyer; Leonard E. Foote; Robert F. Scott.
Memorials: Joseph P. Linduska.
Nominations: Lee E. Yeager, Chairman; Robert C. Ball; Daniel W. Lay; H. G. Lumsden; Edward C. Raney.
Professional Standards: Joseph J. Hickey, Chairman; Charles A. Dambach; G. O. Hendrickson; P. R. Needham; R. E. Trippensee.
Research Needs: A. Starker Leopold, Chairman; Clarence Cottam; Thomas R. Evans; H. B. Mills; M. O. Steen; S. C. Whitlock.
Resolutions: Albert E. Hyder, Chairman; Kenneth E. Hungerford; Fred W. Johnson; H. R. Newcomb; Bruce S. Wright.
Wetland Management: Hayden W. Olds, Chairman; William P. Baldwin; E. B. Chamberlain, Jr.; John E. Chattin; James W. Kimball; William H. Marshall; Lyle S. St. Amant.
Wildlife Nomenclature: William H. Elder, Chairman; Rollin H. Baker; Carlton M. Herman; Eugene P. Odum; Philip L. Wright.

Chairman, Technical Sessions, 1953 No. Am. Wildlife Conference: Victor H. Cahalane.
Representative to the National Research Council: Durward L. Allen.
Representative to the International Union for the Protection of Nature: Victor H. Cahalane
Representative to the Natural Resources Council of America: Clarence Cottam.